THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

www.epemag.com

BUILD AN AIR QUALITY MONITOR

- Indicates carbon dioxide and monoxide levels
- Colour-coded bargraph display
- Triggers audible alarm at preset concentrations
- Use in your home, boat, caravan or any enclosed space

GPS CAR COMPUTER – PART 2

Software, set-up and interface with a laptop

WIN A MICROCHIP PICkit 3 Debug Express Kit

RECYCLE-IT – WIND-POWERED LED FLASHER

WEB SERVER IN A BOX – PART 3

Customising the server for your requirements

PLUS

INTERFACE, INGENUITY UNLIMITED, PIC N' MIX
READOUT, NET WORK, CIRCUIT SURGERY, TECHNO TALK

$8.99US £4.25UK
FEB 2012 PRINTED IN THE UK

New 8-bit Microcontrollers with integrated configurable logic in 6- to 20-pin packages

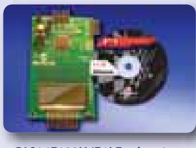
Microchip's new PIC10F/LF32X and PIC12/16F/LF150X 8-bit microcontrollers (MCUs) let you add functionality, reduce size, and cut the cost and power consumption in your designs for low-cost or disposable products, with on-board Configurable Logic Cells (CLCs), Complementary Waveform Generator (CWG) and Numerically Controlled Oscillator (NCO).

The Configurable Logic Cells (CLCs) give you software control of combinational and sequential logic, to let you add functionality, cut your external component count and save code space. Then the Complementary Waveform Generator (CWG) helps you to improve switching efficiencies across multiple peripherals; whilst the Numerically Controlled Oscillator (NCO) provides linear frequency control and higher resolution for applications like tone generators and ballast control.

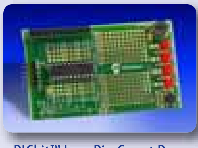
PIC10F/LF32X and PIC12/16F/LF150X MCUs combine low current consumption, with an on-board 16MHz internal oscillator, ADC, temperature-indicator module, and up to four PWM peripherals. All packed into compact 6- to 20-pin packages.

FAST-START DEVELOPMENT TOOLS

PICDEM™ Lab Development Kit - DM163045



PIC16F193X 'F1' Evaluation Platform - DM164130-1



PICkit™ Low Pin Count Demo Board - DM164120-1

Free CLC Configuration Tool:
www.microchip.com/get/euclctool

Go to www.microchip.com/get/eunew8bit to find out more about low pin-count PIC® MCUs with next-generation peripherals

microchip DIRECT www.microchipdirect.com

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MICROCHIP

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• PROJECTS • THEORY •
• NEWS • COMMENT •
• POPULAR FEATURES •
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EPE EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

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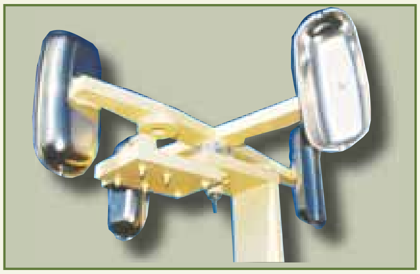


Projects and Circuits

Series and Features

Regulars and Services

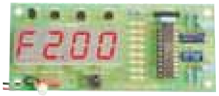
Our March 2012 issue will be published on Thursday 2 February 2012, see page 72 for details.

Everyday Practical Electronics FEATURED KITS February 2012

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested Down Under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

Vehicle G-Force Meter Kit

KC-5504 £18.25 plus postage & packing



Measure the g-forces on your vehicle and it's occupants during your next lap around the race circuit, or more sensibly use this kit to encourage smoother driving to save petrol and reduce wear & tear. Based around an accelerometer IC, this kit displays the forces (+/- 2g) on the 4-digit LED display. It is not limited to cars either; use it to measure g-forces on a boat crashing over waves or on a theme park thrill ride. Kit includes PCB with pre-mounted SMD component, pre-programmed microcontroller and all onboard electronic components.

Note: To make the kit more accessible to everyday hobbyists we are suppling the PCB with the SMD component already mounted on the board to save time and frustration.

- Requires 2 x AA batteries
- PCB: 100(L) x 44(W)mm

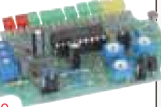
Featured in EPE November 2011

NEW

Voltage Monitor Kit

KC-5424 £8.50 plus postage & packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features 10 LEDs that illuminate in response to the measured voltage, preset 9-16V, 0.-5V or 0-1V ranges, complete with a fast response time, high input impedance and auto dimming for night time driving. Kit includes PCB with overlay, LED bar graph and all electronic components.



- 12VDC
- PCB: 74 x 47mm

Featured in EPE September 2010

Speedo Corrector MkII Kit

KC-5435 £20.00 plus postage & packing

Modifying your gearbox, diff ratio or changing to a larger circumference tyre may result in an inaccurate speedometer. This kit readjusts the speedometer signal up or down from 0% to 99% of the original signal. This upgraded model enables automatic input setup selection and indicates when the input signal is being received. Kit supplied with PCB with overlay and all electronic components.

- PCB: 105 x 61mm
- Recommended box UB5 use (HB-6013 £1.50)

SMS Controller Module

KC-5400 £21.25 plus postage & packing

Control appliances or receive alert notification from anywhere. By sending plain text messages this kit will allow you to control up to eight devices. At the same time, it can also monitor four digital inputs. It works with old Nokia handsets such as the 5110, 6110, 3210, and 3310, which can be bought inexpensively. Kit supplied with PCB, pre-programmed microcontroller and all electronics components with manual. Requires a Nokia data cable which can be readily found in mobile phone accessory stores.

Featured in EPE March 2007

Digital Audio Delay Kit

KC-5506 £36.25 plus postage & packing

Corrects sound and picture synchronization ("lip sync") between your modern TV and home theatre system. Features an adjustable delay from 20 to 1500ms in 10ms steps, and handles Dolby Digital AC3, DTS and linear PCM audio with sampling rate of up to 48kHz. Connections include digital S/PDIF and optical Toslink connections, and digital processing means there is no audio degradation. Kit includes PCB with overlay and pre-soldered SMD IC, enclosure with machined panels, and electronic components.

NEW

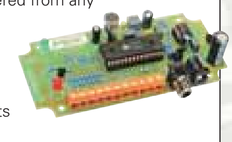
- 9-12VDC power supply required
- Universal IR remote required - use AR-1729 £8.75
- PCB: 103(L) x 118(W)mm

Featured in EPE December 2011

45 Second Voice Recorder Module

KC-5454 £16.00 plus postage & packing

This kit has been improved and can now be set up easily to record two, four or eight different messages for random-access playback or a single message for 'tape mode' playback. Also, it now provides cleaner and glitch-free line-level audio output suitable for feeding an amplifier or PA system. It can be powered from any source of 9-14VDC.



- Supplied with silk screened and solder masked PCB and all electronic components

* PCB: 120 x 58mm

Featured in EPE February 2011

Stereo Compressor Kit

KC-5507 £21.75 plus postage & packing

Compressors are useful in eliminating the extreme sound levels during TV ads, "pops" from microphones when people speak or bump / drop them, leveling signals when singers or guitarist vary their level, etc. Kit includes PCB, processed case and electronic components for 12VDC operation. 12VDC plug pack required - use MP-3147 £6.25

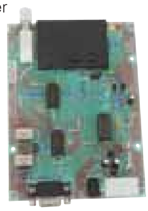
NEW

Featured in EPE January 2012

Full Function Smart Card Reader / Programmer Kit

KC-5361 £20.00 plus postage & packing

Program both the microcontroller and EEPROM in the popular gold, silver and emerald wafer cards. Card used needs to conform to ISO-7816 standards. Powered by 9-12VDC wall adaptor or a 9V battery (not included). Instructions outline software requirements that are freely available on the internet



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- PCB: 141 x 101mm
- Kit supplied with PCB, wafer card socket and all electronic components
- Suitable Wafer Card available, ZZ-8800

Note: Jaycar Electronics will not accept responsibility for the operation of this device, its related software, or its potential to be used for unlawful purposes.

Featured in EPE May 2006

Ultrasonic Antifouling for Boats

KC-5498 £90.50 plus postage & packing

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in a sturdy polyurethane housings. By building it yourself (which includes some potting) you save a fortune! Standard unit consists of control electronic kit and case, ultrasonic transducer, potting and gluing components and housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring. (Price includes epoxies).

- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/wind generator
- PCB: 78 x 104mm

Featured in EPE January 2012

Now available Pre-built:

Dual output, suitable for vessels up to 14m (45ft) YS-5600 £309.25

Quad output, suitable for vessels up to 20m (65ft) YS-5602 £412.25

Pro Gas Soldering Tool Kit

TS-1113 £24.25 plus postage & packing

A sturdy, portable, self-igniting butane powered gas soldering iron tool kit. Produces a 1300°C adjustable flame for low end brazing, tin/plastic melting, automotive repair work, welding and of course heat shrinking. Supplied with 3 interchangeable metal tips, plastic carry case, cleaning sponge and deflector.

- 80-100 min operating time
- Gas capacity: 20ml
- Weight: 115g without gas
- Temperature of torch: Up to 1300°C
- Temperature of hot blow: Up to 650°C
- Temperature of soldering: Up to 500°C
- Torch dimensions: 240(L) x 28(Dia.)mm

NEW

Spare tips and butane gas available separately.

Jaycar Electronics

Freecall order: 0800 032 7241

Essentials for the Electronic Enthusiast

KIT OF THE MONTH

Minimaximite Controller Kit

KC-5505 £18.25 plus postage & packing

A versatile and intelligent controller to interface with your creations, such as home automation. Features 20 configurable digital/analog I/O ports, 128K RAM and 256KB flash memory to hold your program and data. Design and test in MMBasic over a USB link from your PC, then disconnect the PC and the programs continue to operate. Alternatively, hard wire a PC monitor, keyboard, SD card reader and amplified speaker to work independent of a PC.

- Requires 2.3 - 3.6VDC (2 x AA or use plugpack MP-3310 £7.00). Kit supplied with PCB, pre-programmed and pre-soldered micro, and electronic components.
- PCB: 78(L) x 38(W)mm

Featured in EPE December 2011

Clifford The Cricket Kit

KC-5178 £6.25 plus postage & packing

Clifford hides in the dark and chirps annoyingly until a light is turned on - just like a real cricket. Clifford is created on a small PCB, measuring just 40 x 35mm and has cute little LED insect eyes that flash as it sings. Just like a real cricket, it waits a few seconds after darkness until it begins chirping, and stops instantly when a light comes back on.

- PCB, piezo buzzer, LDR plus all electronic components supplied
- PCB: 40 x 35mm

Top Seller

Solder Fume Extractor

TS-1580 £24.25 plus postage & packing

Designed to remove dangerous solder fumes from the work area. Suitable for use in production lines, service centres, R&D workbenches or the hobbyist. It incorporates a ball bearing high volume fan to maximise airflow which is directed upwards at the rear of the unit to aid in safe dispersion of fumes.

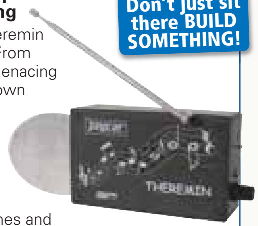
- ESD safe
- Dimensions: 260(H) x 200(W) x 170(D)mm

Theremin Synthesiser Kit MkII

KC-5475 £27.25 plus postage & packing

Don't just sit there BUILD SOMETHING!

The ever-popular Theremin is better than ever! From piercing shrieks to menacing growls, create your own eerie science fiction sound effects by simply moving your hand near the antenna. It's now easier to build with PCB-mounted switches and pots to reduce wiring to just the hand plate, speaker and antenna and has the addition of a skew control to vary the audio tone from distorted to clean.



- Complete kit contains PCB with overlay, pre-machined case and all specified components
- PCB: 85 x 145mm

Illuminated Gooseneck Magnifier

QM-3532 £10.50 plus postage & packing

This handy hobbyist's magnifier has a 2 x main magnifier lens with 5 x insert lens and 2 LED lights, all mounted on a flexible arm. Can be free-standing or clamped to a surface up to 38mm thick.

- Lens 110mm (dia.)
- Stands 225mm high
- Includes protective lens pouch
- Requires 3 x AAA batteries

Desktop LED Magnifying Lamp

QM-3544 £17.25 plus postage & packing

Sixty LEDs provide ample illumination, perfectly even light and the 3x and 12x magnifying lenses will show all the detail you need. Being LED, there's no delay in startup and they'll never need replacing. Ideal for hobbies, modelmaking or jewellery.

- Dimensions: 320(H) x 95(Dia.)mm

Hobby Essentials

PCB Etching Kit

HG-9990 £9.75 plus postage & packing

An ideal kit for anyone needing to etch a circuit board - complete with an assortment of double-sided copper boards, etchant, working bath and tweezers. It also includes a positive acting photosensitive PCB and developer. See web site for full list of inclusions.

Micro Engraver

TD-2468 £7.00 plus postage & packing

The tiny diamond coated tip spins at 10,000 RPM and will engrave glass, ceramics, metals and plastics. Personalise tools, sporting gear, toys, security ID on valuables etc. Batteries and case included. Tip is replaceable.

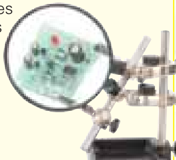
- Size: 160(L) x 15(Dia.)mm

Replacement tip sold separately Cat. TD-2469 £2.50

PCB Holder with Magnifying Glass

TH-1983 £4.50 plus postage & packing

An extra pair of hands and eyes for those fiddly jobs. Supports PCBs while soldering etc. Features 90mm magnifying glass and two alligator clips. Great for model builders and other hobbyists.



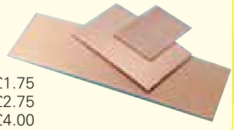
- 145mm high

PC Boards - Vero Type Strip

From £1.75 plus postage & packing

Alphanumeric grid, pre-drilled 0.9mm, 2.5mm spacing.

- 95mm wide x 3 handy lengths

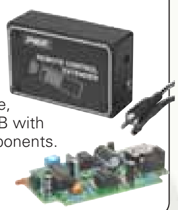


76mm HP-9540	£1.75
125mm HP-9542	£2.75
303mm HP-9544	£4.00

IR Remote Extender MKII Kit

KC-5432 £10.00 plus postage & packing

Operate your DVD player or digital decoder using its remote control from another room. It picks up the signal from the remote control and sends it via a 2-wire cable to an infrared LED located close to the device. This improved model features fast data transfer, capable of transmitting PayTV digital remote control signals using the Pace 400 series decoder. Kit supplied with case, screen printed front panel, PCB with overlay and all electronic components.



- PCB: 79 x 47mm
- Requires 9VDC wall adaptor

DC Relay Switch Kit

KC-5434 £6.25 plus postage & packing

An extremely useful and versatile kit that enables you to use a tiny trigger current - as low as 400μA at 12V to switch up to 30A at 50VDC. It has an isolated input, and is suitable for a variety of triggering options. The kit includes PCB with overlay and all electronic components with clear instructions.

- PCB: 46 x 61mm

Project Tools

Wire Stripper

TH-1824 £6.00 plus postage & packing

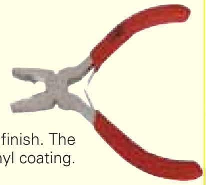
A great way to strip all sorts of cable without damaging the conductors. It automatically adjusts to insulation diameter.

- One hand operation
- Spring return

Bull Nose Plier

TH-1889 £3.25 plus postage & packing

This high quality miniature combination bull nose plier is made from hardened carbon steel with a micro-nickel finish. The handle has a matt red vinyl coating.

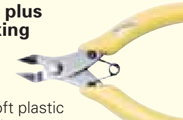


- TUV and GS approved
- 120mm / 4.5" long

Stainless Steel Side Cutter

TH-1890 £5.00 plus postage & packing

High quality small side cutter with 2mm thick blades and comfortable soft plastic spring loaded handles.



Post & Packing Charges

Order Value	Cost
£10 - £49.99	£5
£50 - £99.99	£10
£100 - £199.99	£20
£200 - £499.99	£30
£500+	£40

Max weight 550lb

Heavier parcels POA

Minimum order £10

√ We ship via DHL
√ Expect 5-10 days for air parcel delivery
√ Track & Trace parcel

Note: Products are despatched from Australia, so local customs duty & taxes may apply.

HOW TO ORDER

WEB:	www.jaycarelectronics.co.uk
PHONE:	0800 032 7241*
FAX:	+61 2 8832 3118*
EMAIL:	techstore@jaycarelectronics.co.uk
POST:	P.O. Box 107, Rydalmere NSW 2116 Australia

*Australian Eastern Standard Time (Monday - Friday 09.00 to 17.30 GMT + 10 hours)

All prices in Pounds Sterling. Prices valid until 29/02/2012

Order online: www.jaycarelectronics.co.uk

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Self Assembly Kits & Ready made Modules - See our web site for details on the whole range, Data sheets, Software and more.
www.esr.co.uk
Now Available - Cebek Modules
All modules assembled & tested.
Digital Echo Chamber Kit
A compact sound effects kit, with built-in mic or line in, line out or speaker (500mW). 4 Adjustment controls
Power: 9Vdc 150mA
MK182 Velleman kit £11.43
Digital Record/Player
Non volatile flash memory, Single 20 sec recording via integral mic, 2W output to 8Ω speaker.
Power: 5Vdc 100mA
C-9701 Cebek Module £7.89
3rd Brake Light Flasher Kit
Works with any incandescent or LED rear centre brake light. Flashes at 7Hz for 5 or 10 times, adjustable retriggering.
Power: 12Vdc max load 4A
MK178 Velleman kit £6.30
Multifunction Up/Down Counter
An up or down counter via on-board button or ext input. Time display feature. Alarm count output. 0-9999 display.
Power: 9-12Vdc 150mA
K8035 Velleman kit £17.85
2 Digital Counter
Standard counter, 0 to 99 from input pulses or external signal. With reset input, 13.5mm Displays,
Power: 12Vdc 90mA.
CD-9 Cebek Module £12.99
Digital Clock Mini Kit
Red 7 Segment display in attractive enclosure, automatic time base selection, battery back-up, 12 or 24Hr modes.
Power: 9Vac or dc
MK151 Velleman kit £15.09
Nixie Clock Kit
Gas filled nixie tubes with their distinctive orange glow. HH:MM display, automatic power sync 50/60Hz
Power: 9-12Vac 300mA
K8099 Velleman kit £64.96
1.8W Mono Amplifier
Compact mono 1.8W RMS 4Ω power stage, short circuit & reverse polarity protection. 30-18kHz, Power: 4-14Vdc 150mA
E-1 Cebek Module £5.87
Proximity Card Reader Kit
A simple security kit with many applications. RFID technology activates a relay, either on/off or timed. Supplied with 2 cards, can be used with up to 25 cards. Power: 9Vac or dc
MK179 Velleman kit £14.25
Mini USB Interface Board
New from Velleman this little interface module with 15 inputs/outputs inc digital & analogue in, PWM outputs. USB Powered 50mA, Software supplied
VM167 Module £26.80
20W 2 Channel Amplifier
Mono amplifier with 2 channels (Low & High frequecy), 20W RMS 4Ω per channel, adjustable high level. 22-22kHz, short circuit & reverse polarity protection.
Power: 8-18Vdc 2A
E-14 Cebek Module £22.11
Running Microbug Kit
Powered by two subminiature motors, this robot will run towards any light source. Novel shape PCB with LED eyes.
Power: 2 x AAA Batteries
MK127 Velleman kit £9.02
Thermostat Mini Kit
General purpose low cost thermostat kit. +5 to +30°C Easily modified temperature range/min/max/hysteresis 3A Relay
Power: 12Vdc 100mA
MK138 Velleman Kit £4.55
5W Stereo Amplifier
Stereo power stage with 5W RMS 4Ω, 30-18kHz, short circuit & reverse polarity protection.
Power: 6-15Vdc 500mA
ES-2 Cebek Module £21.54
200W Power Amplifier
A high quality audio power amp, 200w music power @ 4Ω 3-200kHz Available as a kit without heatsink or module including heatsink.
K8060 Velleman kit £12.85
Heatsink for kit £9.95
VM100 Module £38.54
Velleman Function Generator
PC Based USB controlled function generator. 0.01Hz to 2Mhz Predefined & waveform editor. Software supplied. See web site for full feature list.
PCGU1000 Velleman £118.38
12Vdc Power Supply
Single rail regulated power supply complete with transformer. 130mA max, low ripple, 12Vdc with adjustment.
FE-103 Cebek Module £13.16
MP3 Player Kit
Plays MP3 files from an SD card, supports ID3 tag which can be displayed on optional LCD. Line & headphone output. Remote control add-on. Power: 12Vdc 100mA
K8095 Velleman kit £39.99
Velleman PC Scope
PC Based USB controlled 2 channel 60Mhz oscilloscope with spectrum analyser & Transient recorder. 2 Scope probes & software included. See web site for full feature list.
PCSU1000 Velleman £249.00
1-180 Second Timer
Universal timer with relay output. Time start upon power up or push button. LED indication. 5A Relay
Power: 12Vdc 60mA
I-1 Cebek Module £12.92
DC to Pulse width Modulator
A handy kit to accurately control DC motors etc. Overload & short circuit protection. Input voltage 2.5-35Vdc, Max output 6.5A.
Power: 8-35Vdc
K8004 Velleman kit £9.95
Velleman PC Scope/Generator
PC Based USB controlled 2 channel oscilloscope AND Function generator. Software included. See web site for full feature list.
PCSGU250 Velleman £113.67
Cyclic Timer
Universal timer with relay output. Time start upon power up or push button. On & Off times 0.3-60 Seconds, LED indication. 5A Relay
Power: 12Vdc 80mA
I-10 Cebek Module £14.12
Audio Analyser Kit
A small spectrum analyser with LCD. Suitable for use on 2, 4 or 8Ω systems. 300mW to 1200W(2Ω) 20-20kHz Panel mounting, back-lit display. Power: 12Vdc 75mA
K8098 Velleman kit £31.65
RF Remote Control Transmitter
Single channel RF keyfob transmitter with over 13,122 combinations. Certified radio frequency 433.92MHz.
Power: 12Vdc 2mA (inc) For use with TL-1,2,3,4 receivers.
TL-5 Cebek Module £14.64
Light Detector
Adjustable light sensor operating a relay. Remote sensor & terminals for remote adjustment pot. 5A Relay
Power: 12Vdc 60mA
I-4 Cebek Module £13.98
USB DMX Interface
512 DMX Channels controlled by PC via USB. Software & case included. Available as a kit or ready assembled module.
K8062 Velleman kit £47.90
VM116 Module £67.15
RF Remote Control Receiver
Single channel RF receiver with relay output. Auto or manual code setup. Momentary output, 3A relay
Power: 12Vdc 60mA For use with TL-5 or TL-6 transmitters.
TL-1 Cebek Module £28.25
Liquid Level Detector
A liquid level operated relay. Remote sensor operates relay when in contact with a liquid. 5A Relay
Power: 12Vdc 60mA
I-6 Cebek Module £13.08
USB Interface Board
Featuring 5 in, 8 digital outputs, 2 in & 2 analogue outputs. Supplied with software. Available as a kit or ready assembled module.
K8055 Velleman kit £24.80
VM110 Module £34.90
Keypad Access Control
An electronic lock with up to ten 4 digit codes. Momentary or timed (1-60ec/1-60min) output. Relay 5A
Power: 12Vdc 100mA Keypad included.
DA-03 Cebek Module £54.26
Thermostat
A temerature controlled relay. Adjustable between -10 to 60°C Sensor on remote PCB. Connector for external adjustment pot. 5A Relay
Power: 12Vdc 60mA
I-8 Cebek Module £12.80
8 Channel USB Relay Board
PC Controlled 16A relays with toggle, momentary or timed action. Test buttons included, available in a kit or assembled.
K8090 Velleman kit £39.95
VM8090 Module £58.40
AC Motor Controller
A 230Vac 375W motor speed control unit giving 33 to 98% of full power.
Power: 230Vac
R-8 Cebek Module £12.14
Start / Stop Relay
Simple push button control of a relay. Either 1 or 2 button operation 5A Relay
Power: 12Vdc 60mA
I-9 Cebek Module £12.83
Components
Hardware
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EVERYDAY PRACTICAL ELECTRONICS

Share and share alike

Welcome to the first issue of 2012; I hope you had a great festive break.

It's good to see *Recycle It*! back in *EPE*, and I hope we will be carrying more of Julian's imaginative articles this year. I mention this because I have been doing my own small bit for the recycle community this week, and I have a handy recommendation for readers.

My usual route to recycling is to simply place unwanted, but potentially useful items on the pavement just outside my house. A massive A3 laser printer, so big I could hardly carry it down stairs, went within 20 minutes today. Depositing things outside works fairly well where I live. There is a drive, so the pavement is not obstructed, and because I am near the centre of Brighton and it's a reasonably busy road I get plenty of passing traffic. But, what if you don't live in such a convenient place, where large items might cause an obstruction; or perhaps your road is nice and quiet – good for a peaceful life, but not so great for feeding the recycling 'magpies'?

One possible answer is an easy-to-join and easy-to-use website called Freecycle: **www.freecycle.org/group/uk**. You can think of it as eBay without fees, postage costs or prices. For many areas, there are local groups, where you can advertise your unwanted item to people who live near you.

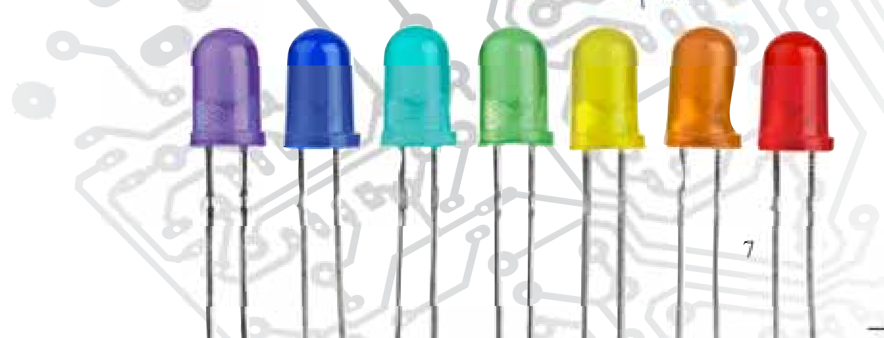
I'm a keen photographer, but ever since I went completely digital I have no longer needed my nice collection of Ilford darkroom paper. It's not actually worth anything, because although the paper still prints beautifully, the boxes are opened and the paper is past its official sell-by date. Still, it seemed a terrible waste to throw away several hundred sheets of high quality paper. I put a couple of sentences on Freecycle, offering the paper, and within hours had half a dozen replies. A student who is learning how to print chemically now has a good range of paper that she can use very cheaply without worrying about the cost of mistakes.

Checking the Freecycle list, I noticed dozens of items that would help those wanting to do electronics on the cheap. Printers, scanners, TVs, Christmas lights, old audio equipment and much else are available – all for free. You can also put up a wanted list.

So, in what looks uncomfortably like another year of economic austerity, please think twice before permanently disposing of 'electronic junk'; someone may well take it away and provide a good second life for your silicon discards.

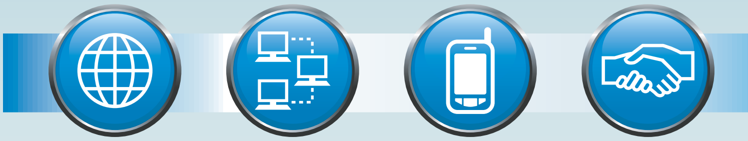
PLEASE NOTE

From next month (March 2012 issue) *EPE* will be published on the **FIRST** Thursday of each month i.e. the March issue will be published on Thursday 2 Feb. This is a change to the previous publishing schedule.



NEWS

A roundup of the latest Everyday News from the world of electronics



Government gives a boost to UK presence at CES by Barry Fox

Visibly straining to avoid any mention of Europe's annual *IFA* consumer electronics show in Berlin, the Consumer Electronics Association (CEA) of the US staged a heavy-duty promotion event in London for *CES*, 'the world's largest consumer technology tradeshow' in Las Vegas.

Gary Shapiro, president and CEO of CEA, promoted and offered to sign his new book, *How Innovation will restore the American Dream*, after announcing a new 'partnership' with the UK government's Trade & Investment body (UKTI), the government department charged with helping UK-based companies succeed in the global economy. Official representatives of the UKTI were on hand to help promote the deal; which, they said, happened because Shapiro heard about the UKTI when the UK's Royal Family visited the US.

'Partnering with UKTI to promote British innovation in the technology sector is of great benefit, and further cements the technology industry's collaborative approach' Shapiro told press, trade and analysts, when welcoming 'the UK's relationship with the World's Fair of Innovation'.

'We're very pleased to be involved in the CEA's first event in the UK', said Stephen McGowan, Head of Operations at UKTI.

Nick Baird, chief executive of UK Trade & Investment, said he was 'absolutely delighted to partner CEA'.

But when I asked what the partnership involved, and whether the UK government planned a similar partnership with Europe's IFA in Berlin, Nick Baird visibly struggled to answer, saying he would prefer 'to answer more broadly'. As tactfully as possible, given the open forum, Gary Shapiro explained to the UKTI ceo what IFA was.

Free space

CEA and UKTI are providing free booth space for three small UK tech companies, which won prizes in a UKTI innovation competition. The winner, Blippar, which developed an augmented reality App for Android and iPhones that creates graphic animation when its camera recognises magazine adverts or supermarket product wrappers, also gets free accommodation in Las Vegas. But Blippar said rather ruefully that it must pay for its own travel. The two runners up get no help with accommodation or travel.

Customisable experience

Preceding Gary Shapiro's appearance, Shawn DuBravac, chief economist and director of research and Steve Koenig, director of industry analysis jointly offered upbeat and hopeful views on 'trends expected at the Las Vegas, *2012 International CES*, and the future of the global consumer technology industry.'

Neither speaker offered much by way of hard statistics from named sources, or quantified research, but noted that with Amazon's lead, the UK has now started to embrace the 'Black Friday' concept.

'US consumers have been trained like Pavlov's dogs to respond to Black Friday offers. Your training begins here,' they said, adding that 'CE now has a new meaning – 'customisable experience'. Hardware is becoming an empty vessel. But watch out for 4kx2k TVs at CES, and screens with very narrow bezels, or no bezels at all, which can be used for video screen walls'.

Water leak detector

Clive 'Cool Beans' Maxfield

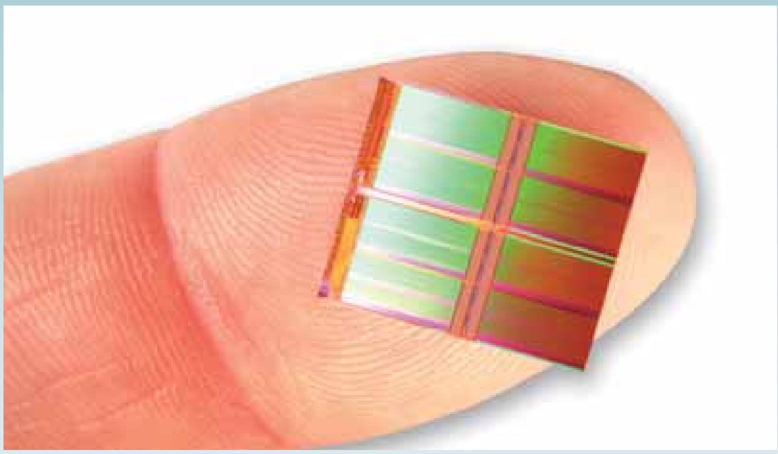
We've just had a water leak at our house (the pipe connecting the fridge-freezer to the wall started to leak). We didn't know it was there for a while, so the result is a lot of damage to the hardwood floors, which will have to be replaced (fortunately our insurance company is on the case).

I started to think that it would be great to have a small electronic dampness detector that you could place behind a fridge or dishwasher. If we'd had one of these, we would have known as soon as the problem started and we could have turned the water off, and saved ourselves a lot of hassle. The idea would be to have something cheap enough that you could put one behind/under every appliance connected to the water supply and also under every sink (kitchen, bathroom), or even behind/under every toilet bowl!

I was thinking about designing/building these myself, and making some money, but it turns out someone already has. You can get a three-pack from Amazon USA for only $22 (I've ordered three three-packs, so I can place these handy devices all around our house).

There are quite a few other models out there, but the ones in the link have a 4-out-of-5 rating from 143 reviewers, which is reasonably good in the scheme of things. See: **www.amazon.com/Zircon-Leak-Alert-Electronic-Batteries/dp/B002Q8GRPG**

INTEL BREAKS NEW BARRIERS



Intel's new 20nm NAND Flash technology 128Gb (one terabit) device – it can hold over a day's worth of high quality video

Intel, with their partner Micron Technology, have announced a new benchmark in NAND Flash technology – the world's first 20nm, 128Gb device.

The new memory device is claimed to be the first in the industry to enable a terabit (Tb) of data storage in a fingertip-size package by using just eight dies. It meets the high-speed ONFI 3.0 specification to achieve speeds of 333 megatransfers per second (MT/s), providing a high performance solid-state storage solution for today's increasingly slim, sleek product designs, such as tablets, smartphones and high-capacity solid-state drives (SSDs.)

The companies revealed that the key to their success with 20nm process technology is due to an innovative new cell structure that enables more aggressive cell scaling than conventional architectures.

The demand for high-capacity NAND Flash devices is driven by three interconnected market trends: data storage growth, the shift to the 'cloud' and the proliferation of portable devices. As digital content continues to grow, users expect that data to be available across a multitude of devices, all synchronised via the cloud.

To effectively stream data, servers require high-performance, high-capacity storage, and storage in mobile devices has consistently grown with increased access to data. High-definition video is one example of an application that requires high-capacity storage, since attempting to stream this type of data can create a poor user experience.

These developments create opportunities for high-performance, small-footprint storage, both in the mobile devices that consume the content, and the storage servers that deliver it.

LEDs lighting the way to the future

A new report from the UK's Energy Saving Trust (EST) argues that LED technology is developing very quickly, and the costs are falling. McKinsey & Company (management consultants) forecast that LED lighting has the potential to be the dominant technology in domestic and commercial lighting by 2015.

The EST conducted a field trial into the feasibility of installing LED lighting into communal areas of social housing, including stairwells, corridors and common rooms. The trial measured the performance, energy-saving potential and maintenance of light levels of over 4,250 LED light fittings across 35 different sites.

The key findings of the trial included:

1. *Lighting levels increased.*
2. *When LED performance is normalised, to account for increased light levels, it is calculated that the trial's LED lighting will generate savings in excess of three million kWh per year. This is equivalent to the energy needed to light 5,788 typical UK homes for a year.*
3. *The LED installations increased the 'colour temperature' in buildings, giving a brighter, whiter light, much closer to that of daylight.*
4. *Using normalised figures, the trial suggested that return on investment could be around two years.*

See: **http://tinyurl.com/c8xcpnx**

On-Site Guide

The Institution of Engineering and Technology (formerly the IEE), has released the *On-Site Guide* to aid the electrical industry's understanding of the amended *IET Wiring Regulations 17th Edition, BS 7671:2008 incorporating Amendment No.1, 2011.*

Geoff Cronshaw, chief electrical engineer at the IET said: 'All electrical installations designed after 31 December 2011 will need to comply with the amended *Wiring Regulations*. As the title suggests, this publication is ideal for practising electricians as a quick reference guide to aspects of the amended *Wiring Regulations*.'

The A5-sized booklet is suitable for all electrical installers, electrical contractors, installation designers and students in further education and professional training. It is designed to present the essential elements of the amended *Wiring Regulations* in a convenient and easy-to-use format and avoids the need for detailed calculations.

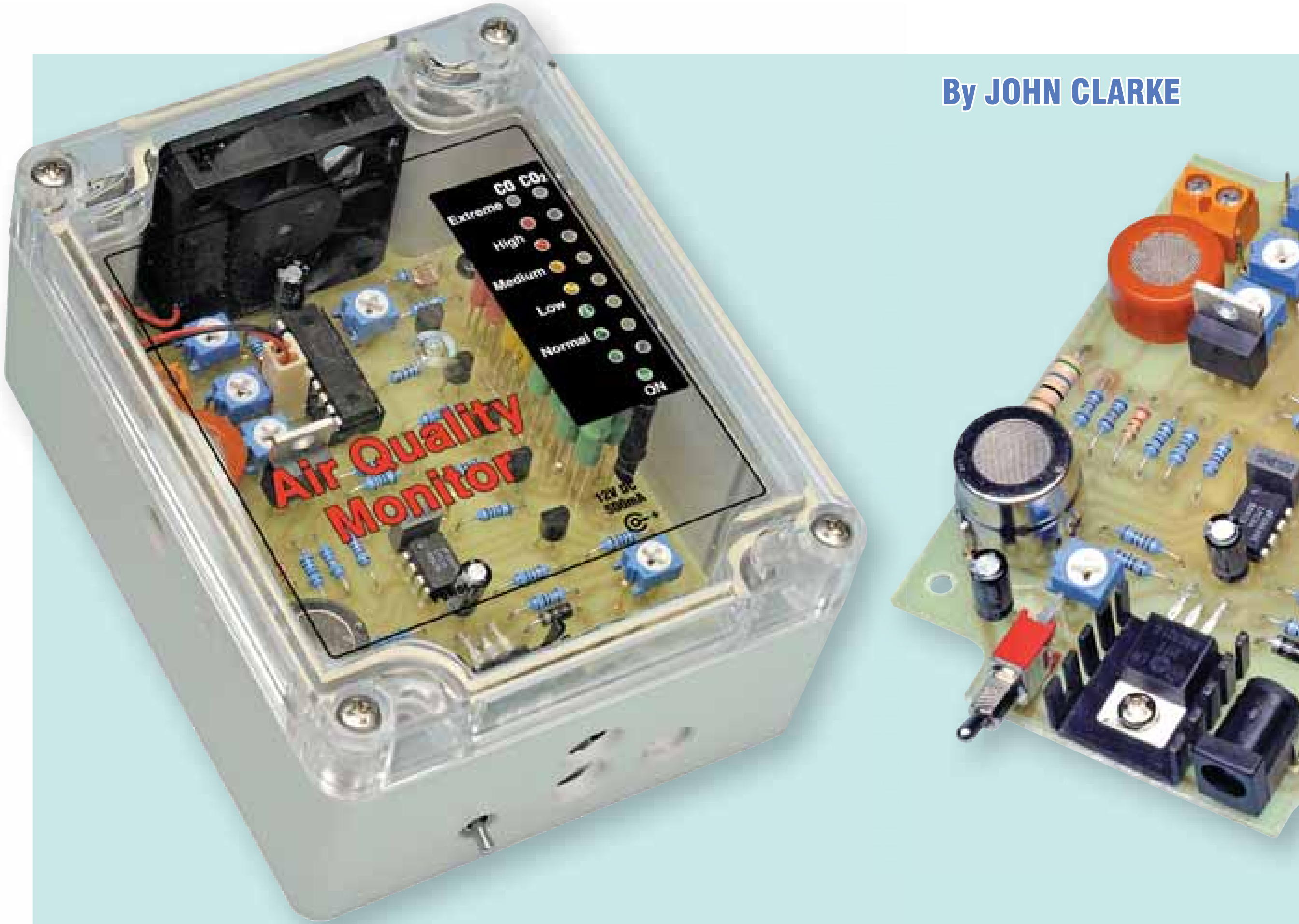
The IET's *On-Site Guide* can be purchased from: **www.theiet.org/osg**

Microchip launches wireless transmitter 8-bit PIC

Microchip has announced the PIC12LF1840T48A, which is the first in a family of single-chip devices that integrate an eXtreme Low Power (XLP) 8-bit PIC microcontroller with a sub-GHz RF transmitter.

The PIC12LF1840T48A's combination of features in a single, 14-pin TSSOP package makes it ideal for space-, power- and cost-constrained applications, such as remote keyless entry fobs for automobiles, garage doors and home security systems, as well as a broad range of other home and building automation systems. The device is also optimised to run Microchip's royalty-free advanced code-hopping technology. For more details, see: **www.microchip.com/get/K4KF**

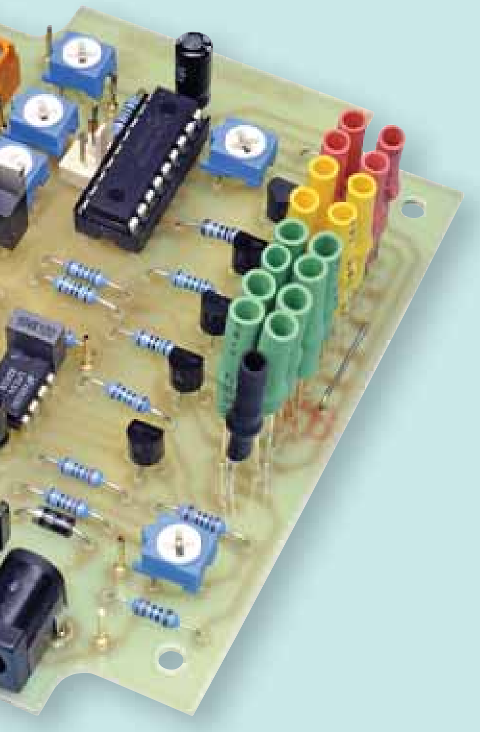
By JOHN CLARKE



Unflued gas heaters are a hazard to health and life . . .

Build an Air Quality Monitor to ensure your safety and well-being

This Air Quality Monitor indicates carbon dioxide (CO_2) and carbon monoxide (CO) levels on a dual bargraph, and sounds an alarm when either level reaches a preset concentration. You should use it if you have an unflued heater in your home, boat, caravan or any indoor space.



Main Features and Specifications

Features

- Detects carbon monoxide (CO) and carbon dioxide (CO_2) levels
- 15-level LED bargraph display for each gas
- Three-stage alarm ranging from initial warning through to urgent
- Internal fan replenishes air for sensors
- Automatic display dimming in low light levels

Specifications

CO_2 range: 0.03% to 1% (300-10,000ppm) with recommended calibration

CO range: 0.003% to 0.03% (30-300ppm) with recommended calibration

Bargraph displays: separate bargraphs to show CO and CO_2 concentrations, each consisting of eight LEDs with 15 display levels.

Alarm modes: 16ms chirp every 16s (third top LED), 32ms chirp every 4s (second top LED) and 64ms chirp every 0.5s (top LED).

CO_2 sensor heating: continuous at 200mA.

CO sensor heating: 60s heating at 150mA; 90s reading period at 42mA.

Readings update: CO = 2.5 minutes; CO_2 = after an initial 60s, then with a nominal 5s lag due to sensor response.

Dimming range: 205 brightness levels.

Diagnostic display: CO sensor only when VR4 is set to give 0V on TP4. The top two LEDs are lit during the heating cycle, while the third top LED and LEDs below light for the measurement cycle, with these LEDs extinguishing successively every 15s.

Power supply: 12V DC 500mA plugpack.

ALL COMBUSTION heaters, including those using wood, coal, coke, kerosene, methylated spirits and gas, draw oxygen from the air as the fuel is burnt. If used indoors, such as inside a house, this gradually reduces the oxygen concentration in the air unless there is sufficient ventilation to the outside. However, judging how much room ventilation is needed to keep the air safe is almost impossible, and it's all too easy to provide insufficient outside air. After all, you do want to keep warm.

If you don't have sufficient fresh air in the room, there is the immediate danger that the deadly gas carbon monoxide will be produced. This is much more likely if the heater is unflued, whereby the combustion gases are released into the room. Many gas heaters are unflued, and every one of these is a potential source of carbon monoxide and other noxious gases.

Not the answer

Some gas heater designs attempt to get around this problem by employing an oxygen depletion sensor. These extinguish the heater if the oxygen concentration in the room is reduced by 20%. While better than having no sensor at all, this definitely should not be regarded as a safe answer.

Why? Because regardless of whether the oxygen depletion sensor, a pretty crude device, is working, the heater may still produce some carbon monoxide as well as the normal combustion products of carbon dioxide, water vapour, nitrogen oxides, sulphur dioxide and formaldehydes.

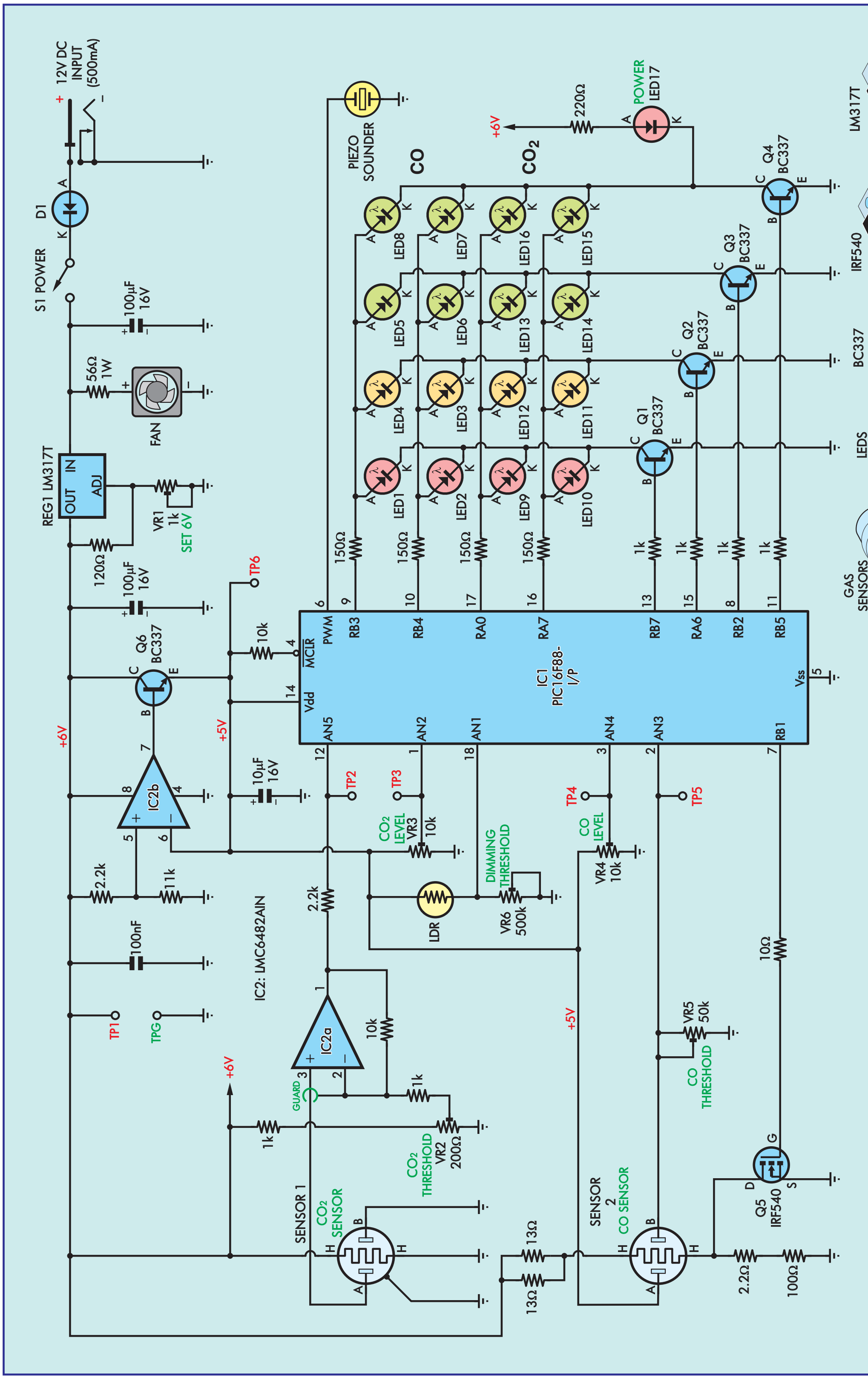
An oxygen depletion sensor does not detect or react to any of these noxious and potentially harmful gases – it only detects a reduction in oxygen concentration.

Even if no carbon monoxide is produced, all unflued gas heaters still produce the other combustion products listed above, and these can cause breathing difficulties for people who suffer from asthma or allergies. Ultimately, unflued gas heaters must be regarded as less than ideal, but they are much cheaper than properly flued gas heaters and most of them have the advantage of using a bayonet gas connector, which allows them to be moved from room to room.

Monitoring air quality

Ideally, if you have a combustion heater in your home, there should be some means of monitoring the air quality. This is where the Air Quality Monitor comes in, it measures both carbon dioxide and carbon monoxide levels, and displays the results on LED bargraphs. If the concentration of either of these gases rises above a preset level, a loud alarm will sound, which means that you should turn off the heater and open the room up to fresh air.

Each bargraph comprises eight LEDs that light individually (ie, one at a time) to show eight distinct levels. In-between values are displayed by lighting two adjacent LEDs. This gives a total of 15 levels that can be displayed. The four lower LEDs are green, followed by two orange and then two red LEDs. An automatic



DIGITAL AIR QUALITY METER

Fig.1: the circuit is based on two gas sensors (Sensor 1 for CO_2 and Sensor 2 for CO) plus a PIC16F88-I/P microcontroller (IC1). IC1 drives a 4 × 4 LED matrix array, with the LEDs arranged to form two bargraphs. IC2b and Q6 provide a +5V rail for IC1.

dimming circuit ensures that the LED displays are not too bright at night.

In addition, the alarm sounds if any of the top three LEDs light in either display. There are three alarm levels:

1) Main alarm sounds if the top LED lights. This consists of a 64ms-long 4kHz tone that repeats every 0.5s
2) Less urgent alarm sounds if the second top LED is lit (top LED off). This alarm gives a 32ms-long 4kHz 'chip' every four seconds (4s)
3) Warning alarm sounds if the third top LED is alight. This alarm mode gives a brief 16ms 4kHz 'chirp' every 16 seconds (16s).

As shown in the photos, the Air Quality Monitor is housed in a plastic case with a clear lid to reveal the LED bargraphs. An internal fan at one end draws air through the box so that the internally mounted CO and CO_2 sensors are presented with a continuous sample of the air that's being monitored. Power for the unit comes from a 12V DC 500mA plugpack.

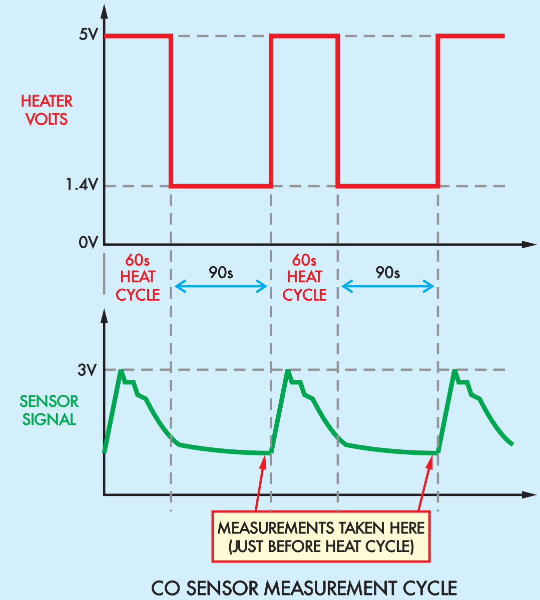


Fig.2: this diagram shows the measurement cycle for the CO sensor. The sensor is initially heated using a 5V supply for 60s, then the heater voltage is reduced to 1.4V for 90s. The CO concentration is measured near the end of this 90s period, after which the heating cycle is repeated.

Circuit details

Take a look now at the Air Quality Monitor circuit of Fig.1. It's based on two gas sensors and a PIC microcontroller (IC1). The microcontroller monitors the sensor signals and drives two multiplexed LED bargraph displays.

We'll start by looking at the CO_2 sensor. This consists of a heater coil and a solid electrolyte cell comprising a lithium (Li) cathode and a potassium (Ka) anode. When these electrodes react with carbon dioxide, a potential difference is produced between them that varies with the CO_2 concentration.

The sensor is built into a metal housing and is exposed to air (and to CO_2) via a stainless steel mesh. Its output in normal air (ie, with a normal CO_2 concentration) is typically 325mV. This voltage falls with increased CO_2 concentrations beyond 400ppm (parts per million) or 0.04%.

The CO_2 concentration in normal air is 0.0314%, but this can increase to 5% in air that's directly exhaled from the lungs. At this latter level, the sensor's output will be well below 250mV (compared to 325mV in standard air).

The CO_2 sensor's output appears across its 'A' and 'B' terminals, and has a very high impedance, so any loading will drastically reduce this output. As a result, the manufacturer recommends monitoring the voltage using a circuit that has a 100GΩ to 10TΩ input impedance and an input current not exceeding 1pA.

To comply with these requirements, we have used an LMC6482 CMOS op amp (IC2a) to buffer the sensor signal. Its input impedance is 10TΩ, while the input current is typically just 0.02pA.

Note, however, that these specifications would not normally be met when the op amp and the sensor are mounted on a PC board, due to leakage current. Fortunately, this leakage current can be prevented by shielding the sensor's output pin and the op amp's pin 3 input with a complete loop of copper track.

As shown, this loop is connected to the op amp's pin 2 inverting input. Because the inverting input is at the same potential as the non-inverting input, no current flows between them and the shield (or guard) track prevents any leakage between pin 3 and other sections of the PC board.

CO_2 threshold

IC2a is wired as a non-inverting stage with a gain of about 11, as set by the 10kΩ and 1kΩ feedback resistors. As a result, a 315mV output from the sensor (ie, in normal air) should result in a 3.47V output from the op amp.

In practice, we found that the output from the particular CO_2 sensor we used was greater than 315mV in normal air, causing IC2a's output to go above 5V. Consequently, trimpot VR2 has been added so that IC2a's output can be level shifted, to correctly set the output to 3.47V in normal air.

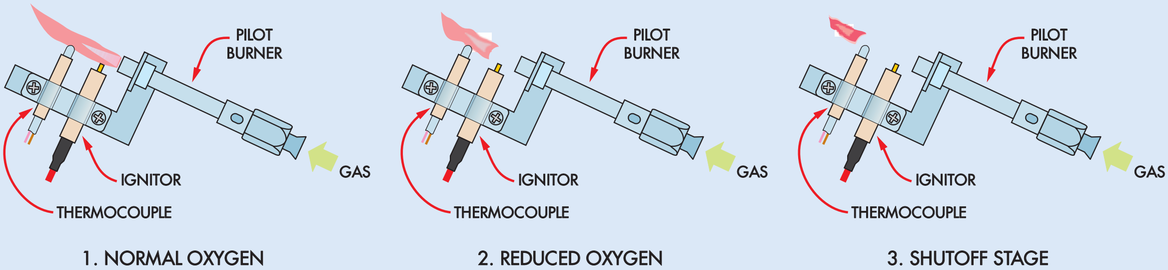
Note that VR2 changes IC2a's gain slightly, depending on its setting, but this doesn't matter in this application.

In practice, VR2 is adjusted so that the lowest LED in the CO_2 bargraph is just off in normal air. By contrast, the maximum bargraph level is adjusted using trimpot VR3, which sets the voltage on the AN2 (pin 1) input of IC1. This voltage is used by IC1 to calculate the display levels.

The amplified sensor signal at the output of IC2a is applied to the AN5 (pin 12) input of IC1 via a 2.2kΩ resistor. An internal analogue-to-digital (A/D) converter then converts the signal to a digital output to drive the bargraph display.

Note that the output from the sensor is valid only after it has been heated sufficiently. This is achieved by connecting a 6V supply across the internal heater element.

How an oxygen depletion sensor (ODS) works



An oxygen depletion sensor consists of a pilot burner, a thermocouple and an ignitor. When the oxygen level in the air is normal (20.9%), the pilot flame touches the tip of the thermocouple as shown at (1). As a result, the thermocouple generates a voltage which indirectly activates an electromagnet and keeps the heater's gas valve open.

When the oxygen level decreases to around 19%, the pilot flame begins to lift and the thermocouple begins to cool (2). Finally, at 18% oxygen, the unstable pilot flame lifts off the thermocouple and its output voltage decreases (3). At that point, the electromagnet closes the gas valve and the heater ceases operation.

The heater can only be restarted when the oxygen level in the room returns to normal.

The effects of CO and CO_2

Carbon monoxide (CO) is a colourless, odourless gas that's made up of molecules comprising one carbon (C) atom and one oxygen (O) atom. By contrast, carbon dioxide (CO_2) molecules consist of one carbon and two oxygen atoms. Over time, CO molecules will pair with a spare oxygen atom to form the more stable carbon dioxide (CO_2) gas.

CO_2 has a concentration of about 0.03% in fresh air and is not dangerous at such low levels. However, higher concentrations result in accelerated breathing, and an increase in heart rate, and can lead to headaches and dizziness. And a concentration of 10% can cause respiratory failure and death within a matter of minutes.

CO_2 concentrations can increase in enclosed spaces when oxygen is combined with carbon to form CO_2, due to combustion and respiration. High CO_2 concentrations are a sure sign that oxygen has been depleted from the air and this can heighten the adverse effects of elevated CO_2 levels.

Poor combustion can result in the production of the oxygen-starved carbon monoxide (CO) gas. Carbon monoxide is extremely dangerous because it has a 200-times greater affinity for haemoglobin than oxygen. As a result, it blocks oxygen from being carried by the blood supply to other parts of the body, including the brain.

Table 3 lists the physiological effects of various concentrations of carbon monoxide in air. As can be seen, even relatively low concentrations can be dangerous.

Table 3: Physiological effects of CO

Concentration	Symptoms
0.005% (50ppm)	No symptoms with prolonged exposure
0.01% (100ppm)	Slight headache within a few hours
0.05% (500ppm)	Headache within 1 hour, increasing in severity over time
0.1% (1000ppm)	Headache, dizziness and nausea within 20-30 minutes; death within two hours
0.4% (4000ppm)	Headache, dizziness and nausea within 5-10 minutes; death within 30 minutes
1% (10,000ppm)	Death in 1-3 minutes

For this reason, the microcontroller ignores readings from this sensor for the first 60s after power is applied.

CO sensor

The output from the CO sensor (Sensor 2) is monitored at the AN3 input (pin 2) of IC1. However, this sensor operates differently from the CO_2 sensor, in that it varies its resistance with CO concentration.

The sensor is made up of a tin dioxide layer deposited onto an aluminium oxide ceramic tube. This tube is fitted inside a plastic housing and is exposed to air (and CO) via a stainless steel mesh.

The specifications state that this sensor must initially be heated using a 5V supply connected across its heater element for 60s. The heater current is then reduced by placing just 1.4V across the element for a 90s period. The CO concentration is then measured, after which the initial 60s heating cycle begins again – see Fig.2.

In practice, this means that measurements are repeated at 2½ minute (150s) intervals.

In our circuit, the heater is powered from a +6V rail via two parallel 13Ω resistors (equivalent to 6.5Ω), while MOSFET Q5 ties the lower end of the heater element to 0V. The heater has a resistance of 33Ω, so when Q1 is on, a current of 152mA flows through it. This results in a 1V drop across the two 13Ω resistors, thus giving the required 5V supply for the heater.

Q5 is controlled by IC1's RB1 output (pin 7) and turns on when its gate is pulled high. In operation, RB1 switches Q5 on for 60s to provide the heating current. RB1 then goes low for 90s, which switches Q5 off, so that the measurement can be made.

During this 90s period (ie, with Q5 off), the CO sensor's heater is effectively in series with the 2.2Ω and 100Ω resistors connected across Q5. As a result, the current through the sensor drops to 42.34mA, which means that the voltage across the heater is now 1.397V (ie, 33 x 0.4234). That is close enough for practical purposes to the 1.4V value specified.

As before, the sensor's output appears across its A and B terminals. This output varies in resistance according to CO concentration, so one side is connected to the +5V rail and the other side to 0V via trimpot VR5 to form a voltage divider.

As a result, any changes in the sensor's resistance (ie, due to CO variations) will result in a corresponding voltage change at the top of VR5. This signal is then applied to the AN3 input of IC1 (pin 2) and fed to its internal A/D converter.

During set-up, VR5 is set so that AN3 is at 0.5V when the sensor is in normal air. However, this signal voltage can rise to around 3V when the CO concentration is over 300ppm.

In operation, the sensor varies its resistance over a 10:1 range for CO concentrations ranging from 10ppm to 1000ppm.

The maximum bargraph level for CO is adjusted using trimpot VR4. It effectively forms a voltage divider across the 5V supply, and its output is applied to the AN4 (pin 3) input of IC1. This voltage, along with the sensor voltage on AN3, is then used by IC1 to calculate the bargraph display level.

Parts List – Air Quality Monitor

- 1 PC board, code 834, available from the *EPE PCB Service*, size 104mm × 78mm
- 1 ABS box with clear lid, 115mm × 90mm × 55mm (Jaycar HB-6246 or equivalent)
- 1 front panel label, 84mm × 80mm, printed onto clear plastic film (eg, overhead projector film)
- 1 CO sensor (Jaycar RS-5615 or equivalent)
- 1 CO_2 sensor (Jaycar RS-5600 or equivalent)
- 1 50kΩ LDR with >1MΩ dark resistance (Jaycar RD-3480 or equivalent)
- 1 12V DC 500mA plugpack
- 1 12V cooling fan, 40mm × 40mm × 10mm
- 1 piezo transducer, 30mm diameter
- 1 2.5mm PC-mount DC power socket (CON1)
- 1 SPDT PC-mount miniature toggle switch (S1)
- 1 2-way screw terminal block, 5.08mm pin spacing (CON2)
- 1 2-way male pin header, 2.54mm pin spacing
- 1 2-way female pin header, 2.54mm pin spacing
- 1 18-pin IC socket
- 1 mini TO-220 finned heatsink, 19mm × 19mm × 9.5mm
- 2 M4 × 12mm countersunk (CSK) screws (to secure fan)
- 2 M3 × 10mm countersunk screws (to secure piezo transducer)
- 1 6mm ID (internal diameter) nylon washer (spacer for piezo transducer)
- 4 M3 × 6mm screws
- 1 M3 × 10mm screw
- 1 M3 nut
- 1 60mm length of 0.7mm tinned copper wire
- 8 PC stakes
- 1 340mm length of black 5mm heatshrink tubing; OR
- 1 160mm length of 5mm green heatshrink tubing, 1 80mm length of 5mm yellow heatshrink tubing and 1 100mm length of 5mm red heatshrink tubing (to match LED colours)

Semiconductors
- 1 PIC16F88-I/P programmed microcontroller (IC1)
- 1 LMC6482AIN dual op amp (IC2)
- 5 BC337 transistors (Q1-Q4, Q6)
- 1 IRF540-N channel MOSFET (Q5)
- 1 LM317T adjustable voltage regulator (REG1)
- 1 1N4004 1A diode (D1)
- 5 3mm red LEDs (LEDs 1 to 2, LEDs 9 to 10, LED17)
- 4 3mm orange LEDs (LEDs 3 to 4, LEDs 11 to 12)
- 8 3mm green LEDs (LEDs 5 to 8, LEDs 13 to 16)

Capacitors
- 2 100µF 16V radial elect.
- 1 10µF 16V radial elect.
- 1 100nF MKT (code 100n or 104)

Resistors (0.25W 1%)

1 11kΩ	1 120Ω
2 10kΩ	1 100Ω
2 2.2kΩ	1 56Ω 5% 1W
6 1kΩ	2 13Ω
1 220Ω	1 10Ω
4 150Ω	1 2.2Ω 5%

Trimpots
- 1 500kΩ miniature horizontal trimpot (VR6)
- 1 50kΩ miniature horizontal trimpot (VR5)
- 2 10kΩ miniature horizontal trimpot (VR3,VR4)
- 1 1kΩ miniature horizontal trimpot (VR1)
- 1 200Ω miniature horizontal trimpot (VR2)

Bargraphs

Two 8-LED bargraphs are used to indicate the CO_2 and CO levels, and these are driven via eight outputs from IC1. These 16 LEDs (LED1 to LED16) are wired in a 4 × 4 matrix, with transistors Q1 to Q4 driving their common cathode (K) connections. Q1 to Q4 are in turn driven by the RB7, RA6, RB2 and RB5 outputs of IC1 via 1kΩ resistors.

In greater detail, transistor Q1 drives the cathodes (K) of LED1, LED2, LED9 and LED10, while their anodes (A) are respectively driven via the RB3, RB4, RA0 and RA7 outputs via 150Ω limiting resistors. Similarly, transistor Q2 drives the cathodes of the second LED column in the matrix, Q3 the third column cathodes and Q4 the fourth column cathodes.

In operation, the LED bargraphs are controlled in multiplexed fashion, with the transistors switched on one at a time in turn. This allows the LEDs in a switched column to be lit individually.

For example, when Q1 is switched on, either LED1, LED2, LED9 or LED10 can be switched on. This is done by taking either RB3, RB4, RA0 or RA7 of IC1 high. Alternatively, by taking more than one of these outputs high,

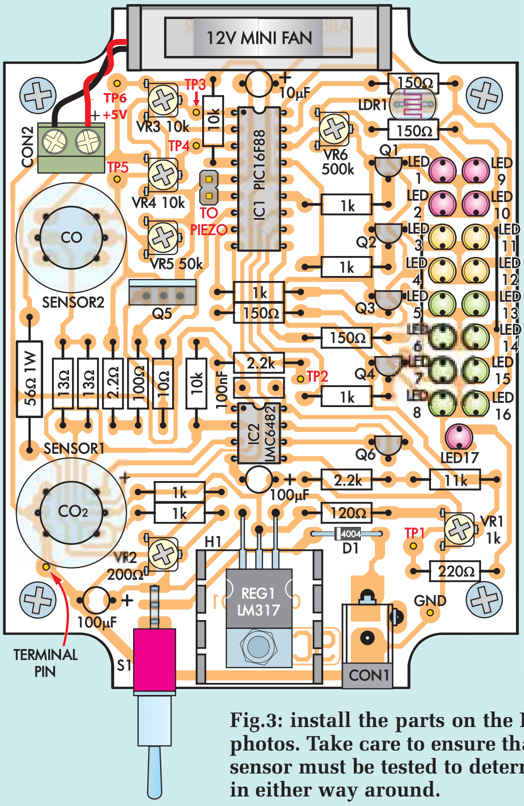


Fig.3: install the parts on the PC board as shown in this layout diagram and the accompanying photos. Take care to ensure that all polarised parts are correctly oriented, and note that the CO_2 sensor must be tested to determine its polarity before it is fitted (see text). The CO sensor can go in either way around.

the LEDs can be switched on in any combination.

The same goes for the other columns in the matrix when their switching transistor is on.

Each transistor is driven on for about 1ms before switching off. As soon as it switches off, the next transistor is switched on to drive the next column of LEDs. However, there is a short gap (or 'dead time') between one transistor switching off and the other switching on, to prevent display errors.

In operation, the LEDs are switched on and off at such a fast rate that they appear to be continuously lit. They are also physically laid out on the PC board as two bargraph columns. The top two rows of LEDs in the matrix (LED1 to LED8) form the CO bargraph, while the bottom two rows (LED9 to LED16) form the CO_2 bargraph.

LED17 is the power on indicator. This connects to the +6V supply via a 220Ω current-limiting resistor, and is driven by transistor Q4 so that it always appears lit when power is applied.

Display dimming

Automatic display dimming is achieved using a light-dependent resistor (LDR). As shown, the LDR is connected in series with trimpot VR6 across the 5V supply to form a voltage divider. The output of this voltage divider is connected to the AN1 input (pin 18) of IC1.

In bright light, the LDR's resistance is 50kΩ or less, and so the voltage applied to IC1's AN1 input is pulled close to the 5V supply. This signals IC1 to drive the LEDs at full brightness.

Conversely, at lower ambient light levels, the LDR's resistance increases and the voltage at AN1 decreases. As a result, IC1 now drives the LEDs with a reduced duty cycle. This is achieved by using a longer dead time, ie, the time between when one transistor switches off and the next one switches on. This effectively reduces the length of time that the LEDs are lit and hence reduces their brightness.

In full darkness, the LDR has a high resistance and VR6 pulls the AN1 voltage down close to 0V. The display is then dimmed to its maximum extent.

Piezo alarm

The alarm feature is provided by using the pin 6 PWM (pulse-width modulation) output of IC1 to drive a piezo transducer. Its frequency of operation is set to 4kHz (50% duty cycle) and there are three alarm modes, as described earlier.

Note that the alarm is only activated when one of the top three LEDs in either bargraph is lit.

Power supply

Power for the circuit is derived from a 12V DC 500mA plugpack, with diode D1 providing reverse polarity protection. The nominal +12V supply rail is then fed via on/off switch S1 to the input of a 3-terminal voltage regulator, REG1, with filtering provided by a 100µF 16V electrolytic capacitor.

This +12V supply rail also drives a 12V fan via a 56Ω resistor. The resistor is there to reduce the fan speed and thus the noise it makes, while still allowing sufficient air to be drawn through the monitor case.

REG1 is an LM317T variable regulator, and is configured to provide a 6V

Above: inside the completed prototype. Light pipes made from heatshrink sleeving are fitted to the bargraph and power LEDs.

supply. The voltage between its OUT and ADJUST pins is nominally 1.25V, but in practice can be anywhere from 1.2V to 1.3V.

If this voltage is 1.25V, this means that a current of 10.4mA flows through the 120Ω resistor and trimpot VR1. Adjusting VR1 to 456Ω sets the voltage across it to 4.75V and the output of the regulator to 6V (ie, 4.75V + 1.25V). This 6V supply is used to drive the heaters in the CO_2 and CO sensors.

In addition, the 6V rail is fed to a voltage divider made up of 2.2kΩ and 11kΩ resistors. The resulting +5V output from the divider is then fed to the pin 5 (non-inverting) input of op amp IC2b, which in turn drives current amplifier Q6 (BC337).

As shown, Q6's emitter (E) provides feedback to IC2b's inverting input (pin 6). As a result, IC2b automatically adjusts its output to maintain +5V at Q6's emitter. This +5V rail powers microcontroller IC1, trimpots VR3 and VR4 and LDR1.

Software

All software program files for the *Air Quality Monitor* will be available from the *EPE* website at: **www.epemag.com**.

Construction

Construction is a snap, with all parts, except the 12V fan and piezo alarm, mounted on a single PC board. This board is coded 834 (104mm × 78mm) and is housed in a 115mm × 90mm × 55mm IP65 ABS box. It has a clear lid so that the LED bargraphs are visible. The printed circuit board is available from the *EPE PCB Service*.

The PC board is designed to mount onto integral standoffs within the box. Begin construction by checking that the PC board fits neatly inside this case. If not, carefully file the edges and/or file the corner cutouts until it does.

Next, check the PC board for breaks in the copper tracks or shorts between tracks and pads. Repair any defects as necessary (they are rare these days), then check that the hole sizes are correct by test-fitting the larger parts (ie, the screw terminal block, regulator REG1, trimpots, sensors and the DC socket).

Check also that the regulator's mounting hole and the corner mounting holes are all 3mm in diameter.

Fig.3 shows the parts layout on the PC board. Start the board assembly by fitting the two wire links and the resistors. The resistor colour codes are

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	11kΩ	brown brown orange brown	brown brown black red brown
❏	2	10kΩ	brown black orange brown	brown black black red brown
❏	2	2.2kΩ	red red red brown	red red black brown brown
❏	6	1kΩ	brown black red brown	brown black black brown brown
❏	1	220Ω	red red brown brown	red red black black brown
❏	4	150Ω	brown green brown brown	brown green black black brown
❏	1	120Ω	brown red brown brown	brown red black black brown
❏	1	100Ω	brown black brown brown	brown black black black brown
❏	1	56Ω 1W 5%	green blue black gold	not applicable
❏	2	13Ω	brown orange black brown	brown orange black gold brown
❏	1	10Ω	brown black black brown	brown black black gold brown
❏	1	2.2Ω 5%	red red gold gold	not applicable

The fan is attached to one end of the case using two M4 × 12mm countersunk screws, while the transducer is secured using M3 × 10mm countersunk nylon screws – see text. Note the ventilation holes in front of the fan.

shown in Table 1, but you should also check each one with a DMM (digital multimeter) just to make sure.

Diode D1 is next on the list, take care to install it with the orientation shown. Once it's in, install PC stakes at all the test points and adjacent to the CO_2 sensor, then install the 2-way pin header for the piezo transducer.

Next, install an 18-pin IC socket for microcontroller IC1, again taking care to orient it correctly (ie, notch towards the top). By contrast, IC2 can be directly mounted on the PC board, and this can go in next. It faces in the same direction as IC1.

The DC socket and the 2-way screw terminal block are next on the list. Be sure to mount the latter with its access holes facing outwards. Transistors Q1 to Q4 and Q6 (all BC337) can then be installed.

Follow these parts with MOSFET Q5 (IRF540). This is mounted vertically with its metal tab towards trimpot VR5 and doesn't require a heatsink.

CO_2 sensor orientation

The CO_2 sensor has a symmetrical pin arrangement and hence will fit the PC board either way around. However, there's nothing on the package to indicate which output is the positive terminal.

This means that the sensor's output has to be checked before it is soldered in place on the PC board. Be sure to follow the step-by-step procedure in the text before fitting this device.

By contrast, regulator REG1 mounts horizontally on the PC board and must be fitted with a small U-shaped TO-220 finned heatsink for cooling.

To install REG1, first bend its two outer leads down through 90° about 7mm from its body and the centre lead down through 90° about 4mm away. That done, fasten the regulator and its heatsink to the PC board using an M3 × 10mm screw and nut, then solder its leads.

Don't solder the regulator's leads before fastening it down. If you do, you could crack the copper tracks as the mounting screw is tightened.

Trimpots (presets) VR1 to VR6 can now all go in. Be sure to use the correct value in each position.

Note that trimpots are often marked with a value code instead of their ohms value. In this case, the code markings will be 102 for the 1kΩ trimpot (VR1), 201 for the 200Ω trimpot (VR2), 103 for the 10kΩ trimpots (VR3 and VR4) and 503 for the 50kΩ trimpot (VR5).

Mounting the LEDs

LEDs 1 to 17 must all be mounted so that their tops sit exactly 30mm above the PC board. The best way to do this is to cut a 25mm-wide thick cardboard spacer, which can then be slid between the leads of each LED – just push the LED all the way down onto the spacers before soldering its leads.

Take care to ensure that the LEDs are all correctly oriented (the anode (A) lead is the longer of the two) and be sure to use the correct colour 'sleeve' at each location – see Fig.3.

Completing the board

Switch S1, the DC socket (CON1), the LDR and the two sensors can now all be installed. Note that the LDR should be mounted with its top surface about 5mm above the PC board.

The CO sensor (Sensor2) in the red plastic housing can go in either way around. **By contrast, the CO_2 sensor (Sensor1), which is in the metal housing, must be tested for polarity before it is installed. The step-by-step procedure is as follows:**

1) Connect short lengths of hook-up wire between each heater pin on the sensor (ie, the centre pin of each set of three pins) and the corresponding pad on the PC board (polarity not important).
2) Plug the appropriate DC connector into the plugpack lead, so that the '+' marking on the connector plug aligns with the '+' marking on the connector socket.
3) Adjust VR1 fully anticlockwise, then connect a digital multimeter between GND and TP1. Set the meter so that it can measure up to 6V DC.
4) Connect the plugpack to the DC socket, switch on and adjust VR1 for a reading of 6V on the DMM. That done, check for +5V on TP6.
5) Connect the multimeter to the A and B terminals of the CO_2 sensor. You should get a reading of 300 to 500mV. Identify which terminal is positive and mark it with a '+' sign.
6) Switch off, disconnect the heater wiring and mount the CO_2 sensor on the PC board with the positive (+) side oriented as shown on Fig.3.
7) Solder the PC stake adjacent to the CO_2 sensor to the sensor's body.

Fitting the microcontroller

You can now fit the microcontroller (IC1) in its socket, taking care with the orientation. That done, apply power again and check that LED17 (the power LED) lights.

If all is well so far, check that this LED dims when the LDR is covered over, and adjust VR6 for best dimming results. (Note: adjustment of the dimming threshold is best done at night.)

Initial adjustments

Before using the unit, it's necessary to adjust the full-scale sensitivity and threshold level of each 'bargraph'

A 6mm ID nylon washer is attached to the top of the transducer before it is installed in the case. This washer can be secured using a light smear of silicone sealant.

display. The initial procedure is as follows:

1) Adjust trimpot VR3 (CO_2 level) to give 3V at test point TP3. This sets the CO_2 full-scale sensitivity to about 10,000ppm or 1%.
2) Adjust trimpot VR4 (CO level) to give 3V at TP4. This sets the full-scale CO sensitivity to about 300ppm.

Note: rotating trimpots VR3 and VR4 clockwise will increase the sensitivity of the CO_2 and CO bargraphs respectively (ie, the display will read higher for a given gas concentration). However, do not rotate VR3 for less than 2V at TP3 or VR4 for less than 2V at TP4.

Conversely, rotating each level trimpot anti-clockwise lowers the sensitivity of its corresponding bargraph.

3) Adjust VR2 so that the bottom LED of the CO_2 bargraph just extinguishes (ie, no LEDs lit). This should be with test point TP2 at just under 3V.
4) Wait 60s after applying power, then blow on the CO_2 sensor to expose it to extra CO_2 gas. Check that the CO_2 bargraph now shows a full-scale reading (ie, top LED lit). If the piezo transducer is connected, check that the alarm sounds with any of the top three LEDs lit.

CO sensor adjustments

Making the adjustments for the CO sensor is a slow process, since it requires a 'burn-in' period of 48 hours. **The unit must, therefore, be left on for 48 hours before making the final adjustments.**

Additionally, as stated in the circuit description, the sensor is heated for 60s and then allowed to respond to the gas over a 90s period before each measurement is made. This means that it will take 2.5 minutes to get the result after each adjustment.

This view shows the power switch and DC socket end of the unit. The air to be monitored is drawn in through the two central holes.

The 12V fan blows the sampled air out through five holes at the other end of the case.

Initially, however, you can bypass the 48-hour burn-in period and make the initial adjustments straight away. The final 'touch-up' adjustments can then be made after the burn-in period.

The first step it to adjust trimpot VR5 so that TP5 is at 0.5V right towards the end of the 90s measurement period, ie, when the sensor is in fresh air. However, this requires some means of monitoring the heating and measurement cycles.

In practice, you can either use a second multimeter to monitor the drain (D) of Q5, or use a diagnostic tool that's built into the Air Quality Monitor that shows the heating/measurement cycles.

The procedure for each method is as follows:

METHOD 1: if you have a second multimeter, connect it between Q5's tab (ie, its drain) and GND. Q5's tab will be close to 0V during the heating cycle and at 4.3V during the measurement cycle. Adjust VR5 to set TP5 to 0.5V near the end of the 90s measurement cycle.

METHOD 2: if using the inbuilt diagnostic tool, start by adjusting VR4 fully clockwise, so that TP4 is at 0V. This will now cause the CO bargraph display to show the heating and measurement cycle.

During the 60s heating cycle, the top two red LEDs will be lit. Then, during the 90s measurement cycle, the red LEDs switch off and the four green and two orange LEDs initially light. These LEDs then extinguish one at a time, starting with the topmost orange LED and continuing at 15s intervals until the bottom green LED goes out at the end of the 90s period.

The unit then reverts to the heating mode again, with the top two LEDs lit.

Note that if VR4 is not set all the way down to 0V, only the top LED will light. Additionally, the alarm will sound if VR4 is set below 2V, so the piezo transducer should be unplugged during this procedure.

Assuming VR4 is set for 0V at TP4, it's just a matter of adjusting VR5 so that TP5 is at 0.5V when the lowest

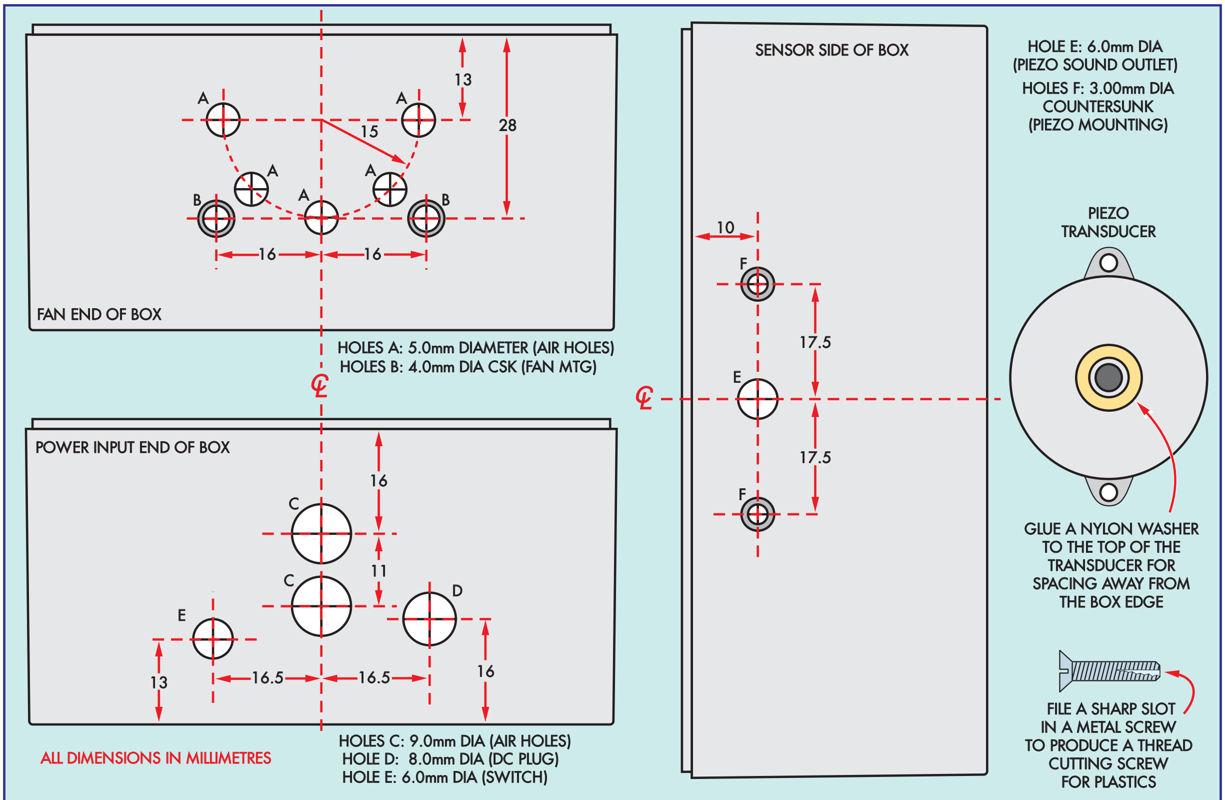


Fig.4: these diagrams can be copied and used directly as drilling templates for the plastic case (the larger holes are best made using a pilot drill and then enlarged to size using a tapered reamer). Also shown are the mounting details for the nylon washer on the transducer, plus the details on modifying a metal screw to so that it cuts a thread in plastic.

one or two green LEDs are alight. **Once that's done, be sure to readjust VR4 so that TP4 is at 3V.**

Testing the CO sensor

The best way to confirm that the CO sensor is working correctly is to expose it to car exhaust fumes for at least 2.5 minutes.

This can be done by first capturing some exhaust in a length of plastic tubing (eg, 120mm × 16mm-diameter) that's closed at one end. The open end is then held over the CO sensor for 2.5 minutes, during which time the CO bargraph display should rise to full scale.

The display should subsequently switch off again a few minutes after the tube is removed. If it does all this, then the sensor and its circuit are working correctly.

As an aside, it's worth noting that the voltage on TP5 has to rise from the 0.5V fresh-air setting to 2V before the lower LED lights on the CO bargraph. This has been done to prevent the CO bargraph from being oversensitive for readings below 30ppm.

Fitting the board in a case

The PC board is designed to fit inside a standard IP65 ABS box with a clear lid (Jaycar HB-6246 or equivalent). Before installing it though, you need to drill a few holes to mount the fan and the piezo transducer. You also need to drill clearance holes for the on/off switch (S1) and the DC power socket, a hole directly in front of the piezo transducer and, intake and exhaust holes for the fan.

Fig.4 shows the drilling details. It can be copied and cut into sections to make drilling templates.

Once the holes have been drilled, glue a 6mm ID nylon washer to the top of the piezo transducer (using silicone sealant), then tap the two mounting holes in the transducer to 3mm. If you don't have an M3 tap, then a modified M3 metal screw will suffice to cut the thread – see Fig.4.

All you have to do is file a slot along the thread of the screw, with a deeper cut at the thread end. This slot will assist in the cutting and removal of the plastic to form the thread in each hole.

Similarly, the two bottom mounting holes in the fan housing must be tapped to 4mm. You can use a modified 4mm machine screw (ie, with a slot) to cut the threads if you don't have a proper M4 tap.

The PC board can now be slid into the case and secured using four M3 x 6mm machine screws. That done, secure the fan using two M4 × 12mm countersunk (CSK) head screws, then install the transducer. The latter is fitted with its attached nylon washer against the side of the case and secured using two M3 × 10mm CSK nylon screws (don't over-tighten these screws).

Next, attach the transducer's leads to the 2-way female pin header (the polarity is not important) and plug it into the matching male header on the PC board. The fan can then be wired to the screw terminal block, with the red lead going to the '+' terminal and the black lead to the '–' terminal.

Now check to make sure that the 10µF capacitor at the top end of IC1 doesn't foul the fan. It may be necessary to bend the capacitor back towards IC1 slightly, to ensure adequate clearance.

LED tubing

Each LED can be made to project its light onto a small spot on the front panel label by fitting it with a small light guide made from heatshrink tubing – see photos. You will need 17 × 20mm lengths of 5mm-diameter heatshrink tubing, it's a good idea to use red, yellow and green tubing, so that it matches the colours of the LEDs. Alternatively, you can just use black heatshrink.

Once the heatshrink tubes have been cut to length, slide them down over their respective LEDs by about 6mm and shrink them down by gently applying heat from a hot-air gun. They should each form a tight grip around the LEDs and be left with a small circle at the top.

Finally, adjust the LEDs so that the 'light pipes' are all in a straight line. Now, when the lid is in place, each bargraph LED will project a small spot onto its correct position when it is lit. The same goes for the power LED.

Front panel label

The front panel label can be made by 'scanning' Fig.5 and printing it out on clear overhead projector film. It is then fitted in place inside the clear plastic lid and secured using neutral-cure silicone sealant at each corner.

Installation

The Air Quality Monitor should be mounted near to the combustion heater and preferably on a wall, so that the display can be easily seen. The box has mounting holes that are accessed with the lid off, so it's easy to fix in position.

Note that it's normal for CO_2 levels to rise while the heater is on. However, the ventilation should be increased if the indicated level rises past the low region on the bargraph.

The carbon monoxide (CO) level in the room should be kept to an absolute minimum and this can be achieved by ensuring that the heater is operating correctly. With wood heaters, this means allowing the temperature to rise sufficiently after the fire has been started, to ensure clean combustion, before reducing the air intake to slow the combustion process.

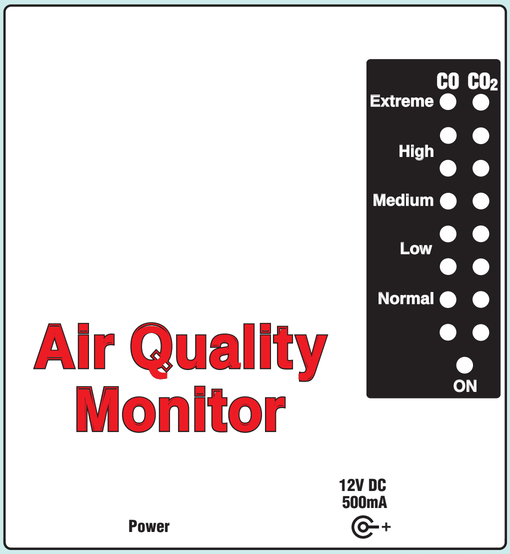


Fig.5: the full-size front panel artwork.

Below: the completed prototype with the label in position. The 'light pipes' fitted to the LEDs ensure that only the correct 'dots' on the bargraphs are lit.

Finally, never use treated or manufactured timber such as treated pine, medium-density fibreboard (MDF), chip board, hardboard or similar in wood fires. These products can produce noxious fumes during combustion. *EPE*

Mighty MIT

Mark Nelson

Imagine a university with more than 10,000 staff, of whom 1,017 are professors. You would expect them to come up with some pretty clever ideas and that's exactly what MIT does. Mark reports on three brilliant electronic discoveries made there lately.

MIT, in case you were unaware, is the Massachusetts Institute of Technology, a US private research university in Cambridge, Massachusetts, US that dates back to 1861. During and following World War II, MIT contributed significantly to the development of radar and it's still 'inventing the future', to use its own slogan.

Artificial leaf

Researchers, led by MIT professor Daniel Nocera, have produced something they're calling an 'artificial leaf'. Like living leaves, the device can turn the energy of sunlight directly into a chemical fuel that can be stored and used later as an energy source. Actually, it's a solar cell bonded to a special catalyst (also developed at MIT Labs) that can harness the sun to split water into hydrogen and oxygen.

It needs no external wires or control circuits to operate. You simply place it in a container of water and expose it to sunlight, streams of bubbles appear rapidly: oxygen on one side, and hydrogen on the other. If you make a container with a separation barrier, the two streams of bubbles can be collected and stored, for instance to feed into a fuel cell that will combine them back into water, delivering an electric current in the process.

No 'unobtainium' is used in the apparatus – just inexpensive, earth-abundant materials (mostly silicon, cobalt and nickel). Ordinary tap water is fine for the 'leaf', unlike the corrosive solutions and expensive platinum used in other devices of this kind.

At the heart of the artificial leaf is a thin sheet of semiconducting silicon – the material used in most solar cells – which turns the energy of sunlight into a flow of wire-free electricity within the sheet. Bonded to one side of the silicon is a layer of cobalt-based catalyst, which releases oxygen. On the other side of the silicon sheet is a layer of a nickel-molybdenum-zinc alloy, which releases hydrogen from the water molecules.

Nocera sees a future in which individual homes could be equipped with solar-collection systems based on this principle. Panels on the roof could use sunlight to produce hydrogen and oxygen that would be stored in tanks, and then fed to a fuel cell whenever electricity is needed.

Graphene photodetector

It's almost a year since we discussed the remarkable electronic, optical and thermal properties of graphene, the new wonder material that's made of a sheet or layer of carbon just one atom thick. Now, researchers at MIT Labs have discovered yet another property of graphene: an unusual thermoelectric response to light. The finding could lead to improvements in photodetectors and night-vision systems, and possibly to a new approach to generating electricity from sunlight too.

When graphene is illuminated by laser light, the electrons in the material are heated, but the lattice of carbon nuclei that forms graphene's backbone remains cool. The differing electrical properties in the two regions create a temperature difference that, in turn, generates a flow of electricity.

This effect works over a very wide energy range, for instance in infrared light, which can be difficult for other detectors to handle. This could make graphene an important component of devices from night-vision systems to advanced detectors for new astronomical telescopes. Other potential applications include the detection of biologically important molecules, such as toxins, disease vectors or food contaminants, many of which give off infrared light when illuminated.

A diode for light

In many of today's long distance communication systems, data travels via light beams transmitted through highly efficient optical fibres. However, once optical signals arrive at their destination, they need to be converted to electrical form, processed through electronic circuits, and then converted back to light using a laser. All-optical data switches and telephone exchanges are not yet commonplace, and those that are in use rely on complex micro-mechanical devices to steer light beams from one fibre path to another.

A new device developed at MIT could eliminate those extra electronic-conversion steps, allowing light signals to be processed directly. Effectively, it's a 'diode for light', says Caroline Ross, the Toyota Professor of Materials Science and Engineering at MIT. Analogous to an electronic diode, where an electric current can flow in one direction, but is blocked from going the other way; the new device creates a one-way street for light, rather than electricity.

According to Ross, the function could be made part of the same chips that carry out other signal-processing tasks. 'The whole system could be made using standard microchip manufacturing machinery,' she says. 'It simplifies making an all-optical chip. The design of the circuit can be produced just like an integrated-circuit, a person can design a whole microprocessor. Now, you can do an integrated optical circuit.'

The benefit for you and me is that light-diode technology could boost the speed of data-transmission systems massively, for two reasons. First, light travels much faster than electrons. Second, while wires can generally carry only a single electronic data stream, optical computing enables multiple beams of light, carrying separate streams of data, to pass through a single optical fibre or circuit without interference. 'This may be the next generation in terms of speed' for communications systems, Ross says.

Finally

If you load a bag with books, you'll soon detect that it weighs a lot more than when empty. But does a Kindle or some other brand of e-reader become any heavier if you load it with thousands of books?

It's not a daft question, according to John Kubiatowicz, a professor of computer science at the University of California, Berkeley, as reported recently in the *New York Times*. The answer is yes, it does. At least in principle, he states.

However, the amount is very small, in the order of an attogram, or 10^{-18}g (10 to the minus 18 grams). 'This amount is effectively immeasurable, even the most sensitive scales have a resolution of only 10^{-9}g'.

'Although the total number of electrons in the memory does not change as the stored data changes,' Dr. Kubiatowicz says, the trapped ones have a higher energy level than the untrapped ones. This energy is equivalent to mass and will therefore have weight.

Assuming that all these bits in an empty four-gigabyte Kindle are in a lower energy state, and that half have a higher energy in a full Kindle, this translates to an energy difference of 17μJ (17 microjoules), he calculated, equivalent to 10^{-18} grams.

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GPS Car Computer

Part 2 – by Geoff Graham

Last month, we introduced our new GPS Car Computer and provided full constructional details. But there's a lot more that we haven't covered yet...

FIRST OF ALL, we'd better run through some of the functions of the *GPS Car Computer* for those who might have missed the last issue. To build it you will, of course, need to refer to the Jan '12 issue.

Operation

In operation the GPS Car Computer is easy to use. There are seven 'screens' that can be displayed and you can step through these screens with the UP and DOWN buttons.

All screens have something that can be configured. For example, on the speedometer you can set the over-speed alarm, and on the clock screen you can set the time zone. To change a setting, press the SET button and then use the UP/DOWN buttons to adjust the value. Pressing the SET button a second time will save the value and return to the main display.

Rather than manually pressing the UP/DOWN buttons to show a new screen, you can put the unit into 'Auto Scan' mode. Now, the display will automatically flip from one screen to the next every three seconds. When it reaches the end, it will wrap around and continue on from the beginning.

To enter Auto Scan mode you simultaneously press both the UP and DOWN buttons. To exit this mode press any button.

To reduce the number of screens on show you can configure the unit to hide some of them. To set this up you must hold down the UP button when you apply power. This will put the unit into a mode where you can set the following characteristics for each screen:

- Show
- Hide in Auto Scan
- Always hide.

The latter is useful if, for example, you have not connected the unit to a fuel injector solenoid and do not want to see the Fuel Economy display. When set to 'Always Hide', the current screen will be skipped as if it did not exist.

The 'Hide in Auto Scan' setting is useful if you want to hide some screens during the Auto Scan mode, but still have them available when you manually step through the screens.

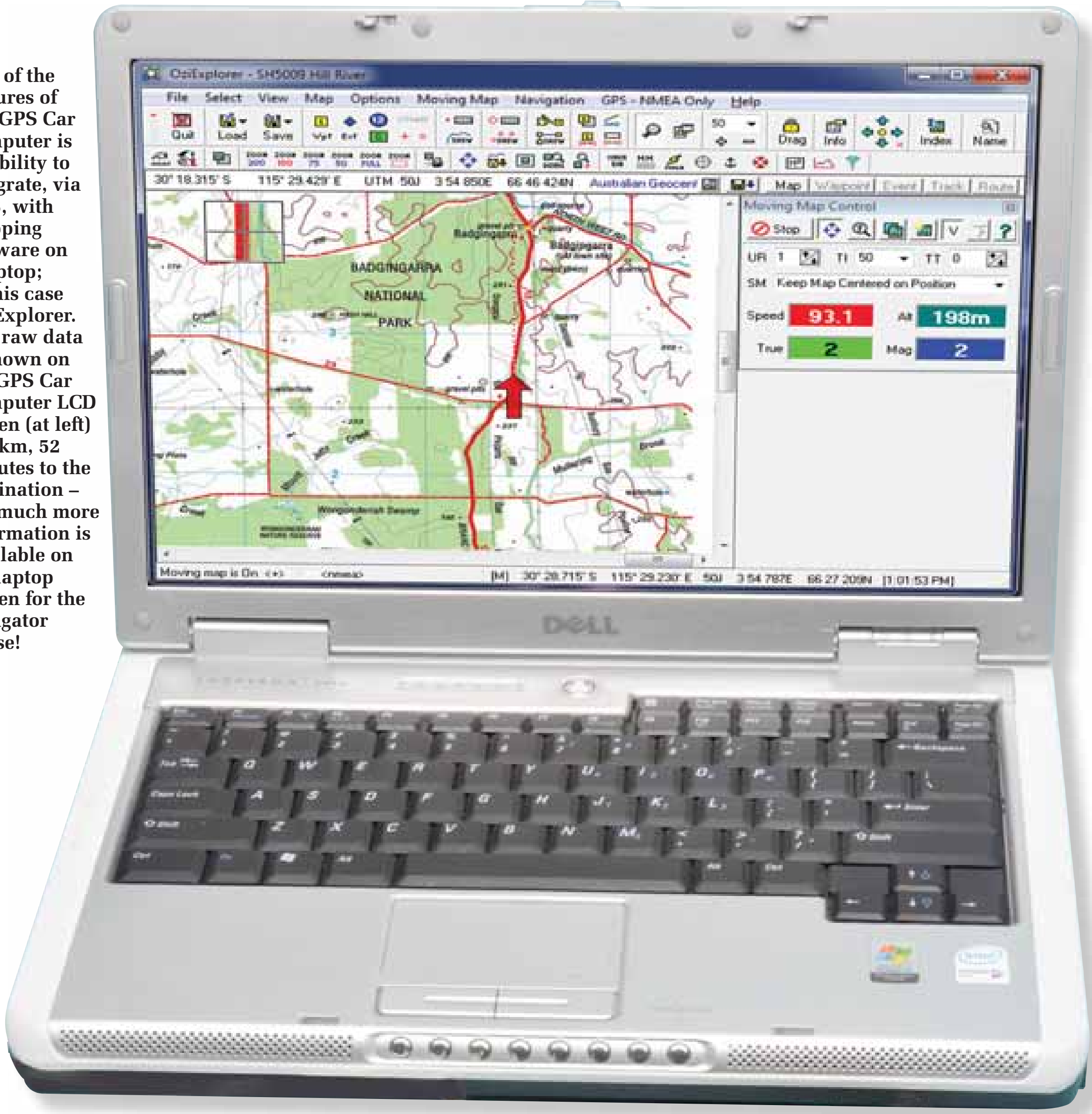
A good example is the 'Signal Levels' screen, which you would not normally need to see.

While in this mode, pressing the SET button will step you through the three settings described above, and the UP and DOWN buttons will move you through the list of screens available for configuration. To exit this mode, you simply remove and reapply the power.

All settings, including the currently showing screen, are automatically saved in non-volatile memory and restored on power-up.

Data display

Most of the displayed data comes from the GPS module; it provides speed, time, heading, altitude, latitude/longitude



One of the features of our GPS Car Computer is its ability to integrate, via USB, with mapping software on a laptop; in this case OziExplorer. The raw data is shown on the GPS Car Computer LCD screen (at left) – 93km, 52 minutes to the destination – but much more information is available on the laptop screen for the navigator to use!

and signal levels. Other displayed data is calculated internally by the microcontroller. The GPS will put out fresh data every second, so this is the update frequency adopted by the microcontroller.

The speed reading is averaged internally by the GPS module, so that the numbers do not jump around with signal noise. As a result, it will take a few seconds for the speedometer to settle down. The other readouts update much faster.

The distance and time-to-destination is calculated by taking the speed every second and working out the distance travelled during that second. This is then subtracted from the total distance to the destination and the result displayed.

While not as accurate as a GPS with in-built maps, it does give a good indication.

This function has two main uses. It is handy when you need to drive along a road for a certain distance to reach a defined point (eg, 'drive for 15km, then turn left').

Three of the more common displays you'll use on the GPS Car Computer. Left is the speedo, arguably quite a bit more accurate than the one on your dashboard! Centre is the distance and time to destination and at right, relative fuel economy.

It is also useful when you need to count down a larger distance. For example, the next town might be 200km away, and you are planning to stop there for lunch. This function will then show you how much longer you will have to put up with hunger pains!

The time-to-destination is calculated by taking into account your average speed over the last 10 minutes. So, if you get stuck behind a slow-moving truck, you can expect to see the time before lunch increase accordingly.

This function is also handy for children who continuously ask 'How much longer daddy?'

Economy meter

The fuel economy meter is another function that is calculated internally by the microcontroller. While it sounds complex, it is actually quite simple to implement.

The microcontroller monitors the percentage of time that a fuel injector solenoid is opened in any second. That, combined with the vehicle speed over the same second, is used to calculate the amount of fuel used per kilometre driven.

This assumes that the pressure in the fuel line to the solenoid remains relatively constant and that all solenoids for all cylinders open for the same amount of time.

For this purpose, these assumptions are close enough, and the upshot is that the percentage of time that the solenoid is open is directly proportional to the amount of fuel consumed by the vehicle.

The result is displayed as a bargraph. A longer bar means that you are consuming more fuel per kilometre than a shorter bar. You can adjust the full-scale sensitivity to suit your car and preferences.

When driving, you should try and keep the bar as short as possible. You will find that during acceleration from a standstill, the consumption will shoot off the scale. Not much can be done about this because to accelerate you are consuming a large amount of fuel for only a small (zero) distance travelled.

At cruising speed, the graph will sit in the middle of the scale and you can vary it markedly depending on your driving habits.

Computer interface

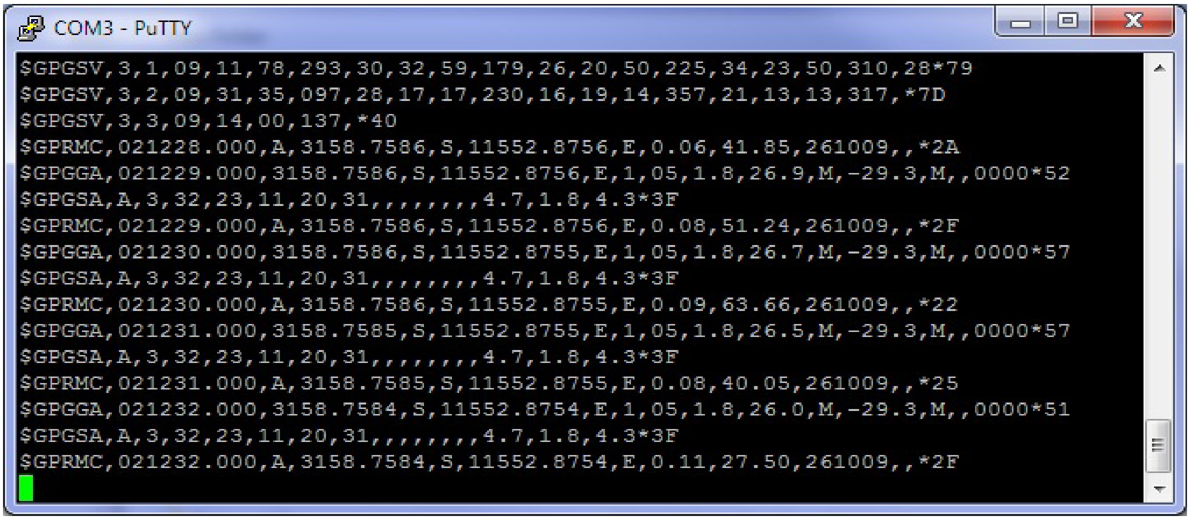
The USB interface allows you to connect to any computer with a USB interface. In this mode, the GPS Car Computer implements a subset of the NMEA-0183 standard for interfacing marine electronic devices, as defined by the US -based National Marine Electronics Association (NMEA). This is an almost-universal standard, and most software will communicate seamlessly with it.

If you search on the Internet, you will find a wealth of software that will allow you to navigate, log your movements, play with the GPS module and much more. We will only cover a few here, but you can check **www.maps-gps-info.com/fgpfw.html**, where over 450 free GPS-related programs are listed.

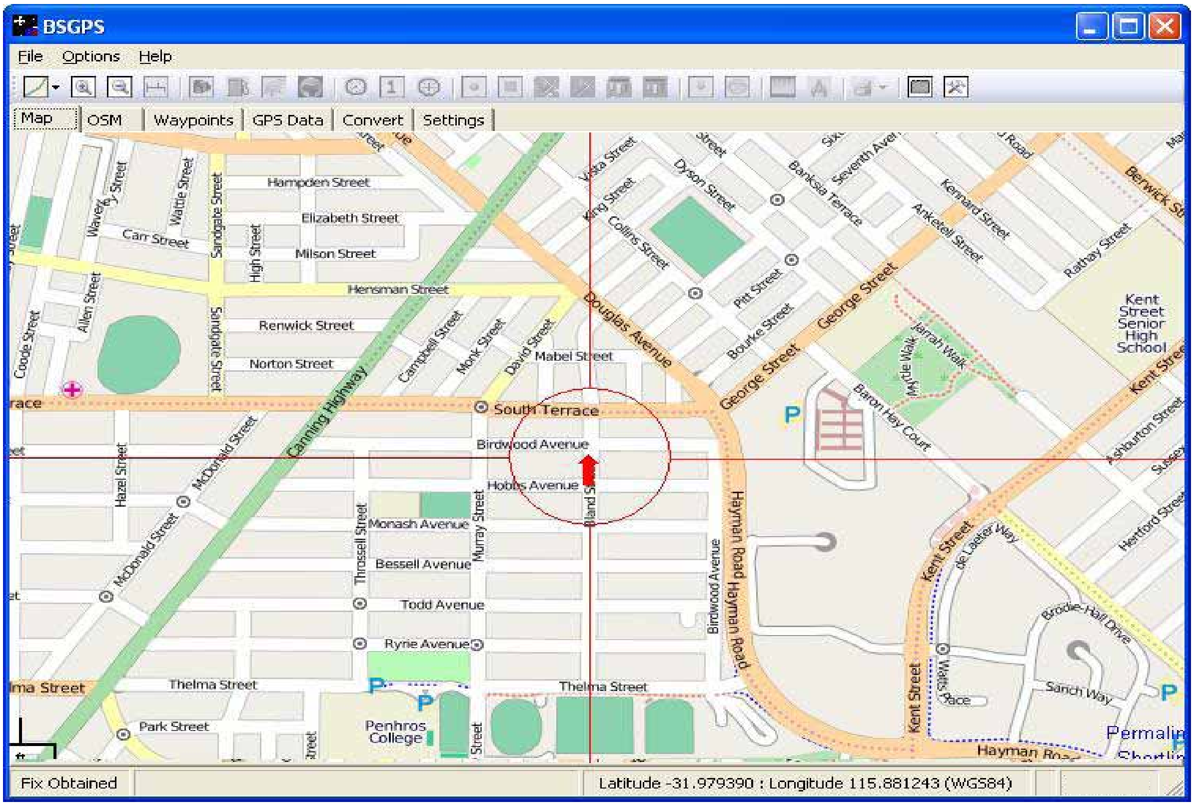
While you are using the USB interface, the GPS Car Computer Display will continue to operate as normal, showing speed, heading and so on. So it is possible for the driver to have whatever data is of interest showing, while a passenger can be separately using a laptop for navigation or other GPS-related functions.

Before you can use the GPS Car Computer with your computer you must install the appropriate device driver. This can be downloaded from the *EPE* website (**www.epemag.com**), where it is listed as 'Silicon Chip USB Serial Port Driver.zip'. The driver will work with Windows 2000, XP, Vista and Windows 7 in 32-bit mode and Vista/Win7 in 64-bit mode. It uses the standard CDC serial interface supplied by Microsoft with all modern versions of Windows, and there are also Linux versions available on the Internet.

The USB standard says that all USB devices must have a unique combination of two 16-bit numbers – the Vendor ID (VID) and Product ID (PID). When you plug in a USB device, the first thing it does is send its VID and PID to your computer, which in turn uses them to locate the correct



This screenshot of the PuTTY terminal emulator program gives a good idea of what the data stream received over the USB interface would look like. The format of the data meets the NMEA-0183 standard, which is a universal communications format used by most GPS-related software.



Here's a screenshot of the BSGPS software using a map downloaded from the OpenStreetMap project and live data from the GPS Car Computer. You can see that we are travelling up Bland St approaching Birdwood Ave – not bad for software and maps that cost nothing.

device driver. If you did not use a unique VID/PID, you could have confusion, where, for example, your computer might try to load the device driver for an Apple iPod.

Manufactures can purchase a Vendor ID (VID) from the USB standards body and then use whatever Product ID (PID) numbers that they need in combination with the VID to differentiate their products. Rather than purchase a whole VID for this project, we sublicensed a single PID from Microchip for use with their corporate VID. These two numbers are used by the GPS Car Computer and the USB Serial Port Device Driver, and ensure that our gadget is legally correct.

Driver installation

After downloading the driver, you should unzip the files into a temporary folder. The method of installing the software varies between versions of Windows, but essentially, when you plug the GPS Car Computer into an USB port the operating system will prompt for a driver. You should then point it to the temporary folder and install from there.

If, for some reason, you are not prompted to install the driver you can navigate to Device Manager, and you should see an entry under Other Devices called 'SC GPS Display'. Right click on that and select Update Driver Software. You can then direct the operating system to the temporary folder.

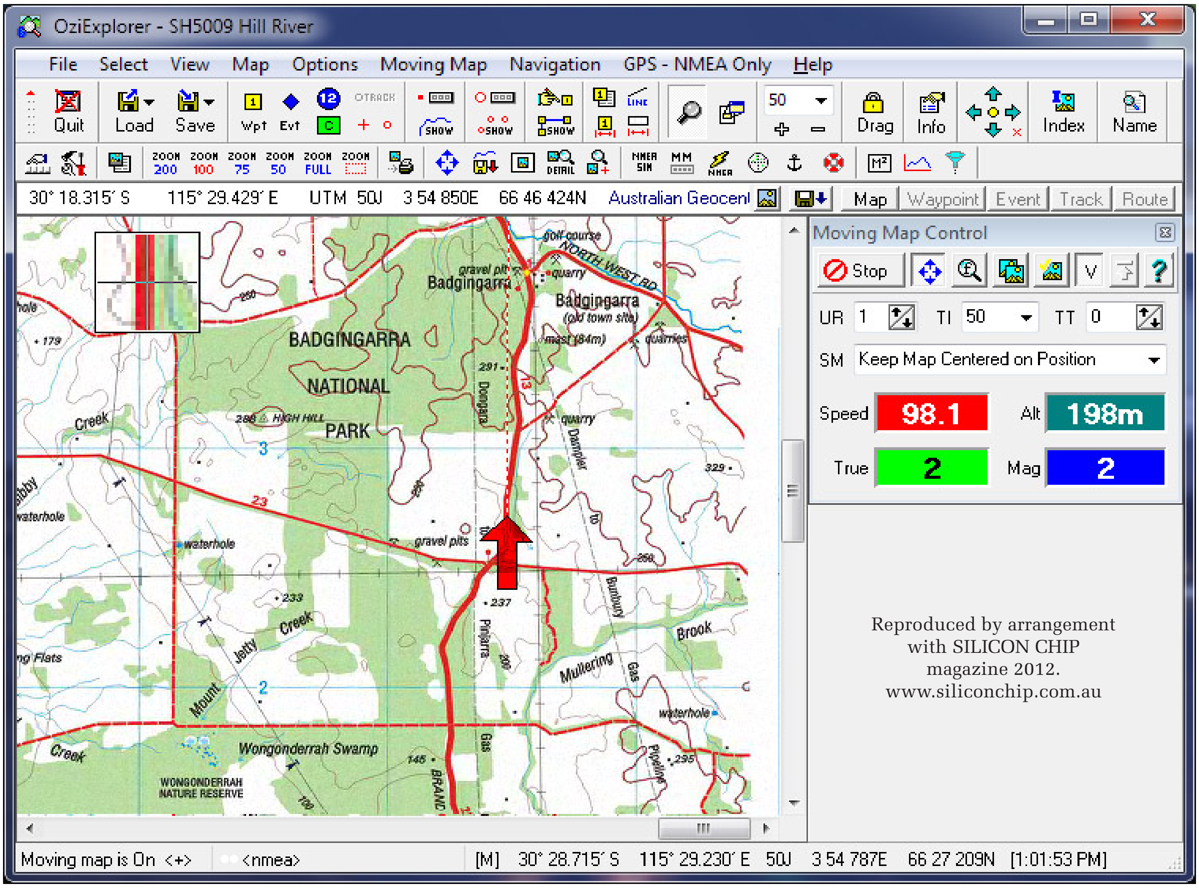
After you have successfully installed the driver, you should see the GPS Display listed in Device Manager under Ports (COM and LPT) as 'Communications Port – Silicon Chip USB Serial Port'. Take note of the COM port number allocated by the operating system, you will need this when configuring software to work with the GPS Car Computer.

In this mode, the GPS Car Computer appears as a virtual serial port in the operating system. You can use any serial terminal emulator such as Hyperterminal, PuTTY, RealTerm or Hercules Terminal Emulator to access the data. When you run the emulator and configure it for the correct COM number you should see the data streaming from the GPS module. The screenshot on the previous page of the PuTTY terminal software gives a good example of what you can expect.

Note that when setting the COM port number, the baud rate and other settings are ignored – the USB Serial Port always runs at the highest speed it can.

A good utility for testing the interface is 'NMEA Monitor' (**http://homepage2.nifty.com/k8/gps**). This will show you the raw data as well as decode the NMEA sentences, and will give you a better insight into what is going on.

Using NMEA Monitor or a terminal emulator, you can also send commands to the GPS module. You should be careful here, as the microcontroller in the GPS Car Computer expects that the module will be in the normal factory default mode, and it may not work if you have changed things too much. In particular, you must be careful not to change the baud rate. The GPS module communicates with the microcontroller at 4800 baud and if you change this, nothing



Here's a larger view of the OziExplorer software shown on the laptop earlier, with a high resolution HEMA map. Position and heading is shown on the map as a red arrow with the tip pinpointing our exact position. This is live data using the GPS Car Computer. The map will move as the vehicle travels, keeping our current position in the centre. The software also shows our speed (98.1Kmh) and altitude (198m).

will work, including your USB serial interface, even if you remove and reapply power.

If you have 'upset' the GPS module, you can try pressing the Down Button while plugging the GPS Car Computer into power. This will cause the microcontroller to send a reset command to the GPS module and may recover the situation, although it is **not** guaranteed. So be careful!

Navigation software

The most impressive use of the computer interface is with navigation software running on a laptop. With it, you can get a moving map, with your position pinpointed exactly.

It is worth noting that this is different from the normal GPS units that you can purchase, such as the TomTom or Garmin devices. These are optimised for city driving and, as a consequence, are focused on taking you to a certain place rather than telling you where you are. In addition the accuracy of their maps is very poor once you get into rural areas.

This is no good for country travellers, and in particular 4WD drivers, who are navigating across country following little used roads or tracks. In this case, you want to see your exact position on a detailed and accurate map. You certainly do not need to be told when to turn right or left as intersections are few and far between, and generally obvious when you come to them.

A typical software package for this type of navigation is OziExplorer with the HEMA map package for Australia (**oziexplorer.com** and **hemamaps.com.au**). Both of these will load on to your Windows-based laptop, and combined will give you the equivalent of a detailed printed map.

The GPS Car Computer works fine with this type of software, and the result is that your exact location will be pinpointed on a high accuracy map with a scale of 250 metres per millimetre (depending on the maps that you bought).

The HEMA maps are rather expensive, so OziExplorer allows you to scan in your own maps, but you still have to buy the software. A number of lower cost alternatives exist, and a good example is BSGPS (**bettersoftware.co.uk**) which is essentially free (they ask for a donation). This software also allows you to scan your maps so you can continue to keep the cost low.

If you mostly keep to the more-populated areas, you can use BSGPS with the OpenStreetMap project (**openstreetmap.org**). This is a free editable map of the world and contains reasonable detail for urban locations. Using BSGPS, you

Loading new firmware

The GPS Car Computer includes a small program which is called a 'bootloader'. This enables you to reprogram (sometimes called 'flashing') the microcontroller using nothing more than a normal Windows computer with a USB port.

To make it easy for us, the GPS Car Computer pretends to be a Microchip PICDEM FS USB board when it is in the bootload mode. That means we can program it using software developed by Microchip to program their own products.

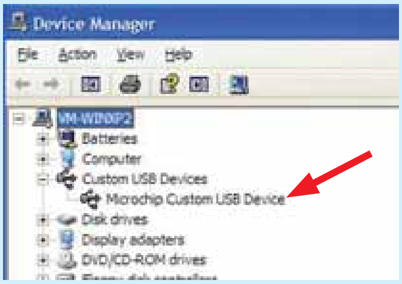
Both the device driver and software described here are compatible with Windows 2000, XP (32 and 64-bit) and Vista (32 and 64-bit). Windows 7 is not supported, but the software does work under the Windows 7 XP Mode. There may also be Linux and Mac versions on the Internet – check the Microchip website or Google for 'MCHPUSB Bootloader' or 'MCHPUSB Driver'.

To start the bootloader, hold down the Set button on the GPS Car Computer while you plug it into a USB port on your computer. If you have not installed a jumper on JP1, you will then have to connect an external 12V power source and hold down the Set button while you plug that in. You can release the button a second or two after.

Your computer should make a sound to signal that it has recognised the GPS Car Computer. Note that when it is in the bootloader mode, the LCD panel will remain blank or may show some random lines, this is normal.

If you have not used the bootloader before on your computer, you will be prompted to install a driver for it. This driver is different from the virtual serial port driver used to receive GPS data from the GPS Car Computer. Your computer may attempt to find a driver currently on your computer or the Internet.

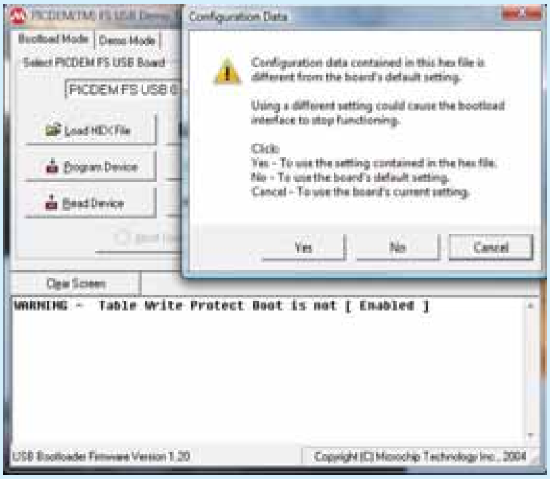
When this fails, select the option to choose your own driver. The device driver is in the directory WinDriver, which should have been created when you unpacked the zip file containing the updated firmware. Navigate to this directory and tell Windows to search there.



When the driver is correctly installed, you should see it listed in Device Manager as a 'Microchip Custom USB Device'.

When you unpack the upgrade zip file, you should also have a directory titled WinLoader, and in that directory will be PDFSUSB.exe. This is the program that uploads new firmware to the GPS Car Computer, and is actually intended for use with the Microchip PICDEM FS USB board. Because of this, it includes many extra features that we will not be using and can safely ignore.

Double-click on PDFSUSB.exe to run the loader. After it has loaded, you can click on the dropdown list and you should see listed PICDEM FS USB, which is what the GPS Car Computer masquerades as while it is in the bootload mode. Click on that entry to select it, then click on 'Load HEX File' and navigate to and select the new firmware that you want to load.

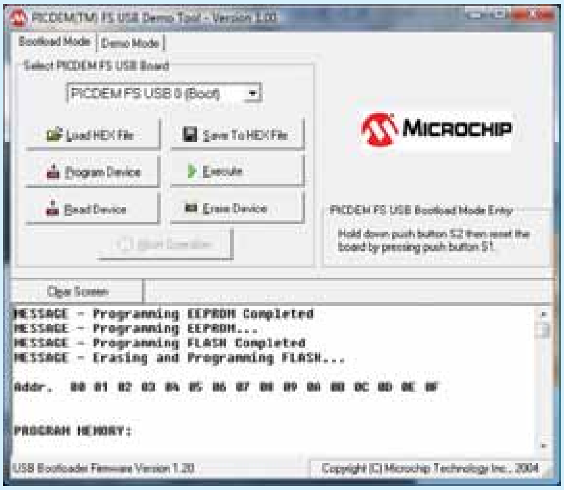


When you load the HEX file, you should see a message warning that the configuration data is different from the board's default setting. Click on Cancel – do not select any other choice, otherwise your firmware will not load correctly.

Finally, click on 'Program Device'. You will see a series of messages, and after about 20 seconds it should display the messages shown in the screenshot, which indicate that the GPS Car Computer has been successfully reprogrammed. You can then unplug the GPS Car Computer and use it as you would normally.

Don't worry about a power failure or accidently unplugging something while it is programming.

If something does goes wrong, you can always restart (ie, unplug, then plug back in while holding down the Set button).



can download the sections that you are interested in and have a very low cost navigation solution.

If you have Internet access on your laptop, you could use the GPS Car Computer with Google Earth to dynamically download and display maps. You could even have your position plotted on a moving satellite image of the country through which you are travelling. Isn't technology wonderful?

External connections

All external connections are made through CON1, a 6-pin mini DIN connector. Ground and 12V are on pin 3 and pin 4 (respectively) of the connector. An external input from the vehicle's headlight's circuit can be wired to pin 1 to control the day/night backlight brightness (more on this can be found in last month's section on 'Assembly options').

Pin 5 of the connector can be wired to a fuel injector solenoid if you want to implement the fuel economy meter function. The 82kΩ and 47kΩ resistors serve to drop the vehicle voltage levels to 5V for the microcontroller (IC1).

There are also two spare connections (pin 6 and pin 2) which can be connected to pin 9 and pin 10 of IC1. These are unused and available for future use. They can be set by the firmware to be digital inputs, digital outputs or analogue inputs. Future firmware updates could use these to measure voltages (eg, battery voltage or sensor outputs), detect digital inputs (eg, switch closure or tachometer output), or set them to be an output to control something.

Firmware

In Part 1 last month, we described the circuit for the GPS Car Computer, but it is in the firmware where the real work is done. We will not go into detail here, but if you are really interested, the source code is available for download from the *EPE* website.

On the surface, it appears that the microcontroller only needs to take the data from the GPS module and display it on the LCD, and that should be simple enough. As usual, the devil is in the detail and the result was rather more complex – the firmware runs to over 7000 lines of C code.

Part of the reason for this size is that we use a graphics display, and while this allow us to turn off or on any pixel, it does involve a much greater overhead to drive. For example, we have to create our own fonts – in total, we use three different fonts, ranging from very large numeric digits for things like the speedometer, through to a small font used for detailed screens like the latitude/longitude display.

Other features, including USB and high speed refresh of the graphic display also add up, so that in the end the firmware uses most of the PIC18F4550's 32KB program space.

In summary, the operation of the firmware is easy to explain. First, there are three interrupts that operate; one when a character is received from the GPS module; one that is triggered by a timer every 85μs; and one when the USB interface has received or sent a packet of data.

The interrupt does just what it says – it interrupts the processor and branches to a different segment of code to do some special processing. For example, when a character is received from the GPS, the interrupt code will retrieve that character and store it in memory. When the last character of a message has been received, the interrupt code will set a flag to indicate that all the data has been received and is available for processing.

Following the interrupt, the processor will return to executing the main program at exactly the spot from where it was interrupted. As a result, the main program is unaware that the processor has been 'hijacked', all it sees is that a flag has been 'magically' set to indicate that there is a message from the GPS ready for processing.

Similarly, the interrupt triggered by the timer every 85μs performs a number of tasks, one of which is to tell if a button has been pressed. There are three flags, one for each of the buttons, and the interrupt code will set the appropriate flag when it detects a valid button press.

Oblivious to the interrupts, the main code runs in a high speed loop, checking these and other flags for something to do. For example, if the main program discovers that the GPS data flag has been set, it will process the data to extract the information that we want. It will then construct an image of the currently showing screen as a bitmap in internal memory and transfer this image at high speed to the LCD's display memory.

State machine

An important part of the main program is that it implements what is called a 'state machine'. Each display on the graphics display is represented as a 'state'. So, when we are displaying the digital speedometer, the state machine is in the 'display speed state'. When adjusting the over-speed setting, the state machine is in the 'set over speed state', and so on.

The state machine is necessary because an event like pressing the Up Button can mean different things, depending on what state the display is in. For example, when displaying the speedometer, the Up Button will cause the display to switch to the clock display, but when adjusting the over-speed setting, the Up Button will increase the setting by one km/h.

The state machine keeps track of the current state and changes states as necessary. It also directs processing according to the event being processed and the state that is current. Generally, a state machine is at the core of most gadgets (eg, microwave, dishwasher etc) and is not very mysterious. If you download the source code for the GPS Car Computer and search for the main() function, you will see the state machine implemented in that function. ***EPE***

WIB
Web Server In a Box

Part 3: By MAURO GRASSI

Last month, in Part 2, we showed you how to connect the WIB to a network and gave the step-by-step setting-up details. Most constructors will settle for the website provided, but for those with specialist needs, here is an article for advanced users who want to customise the WIB to their own requirements.

ONE OF the advantages of the WIB is that you can customise it by designing your own website. For the purposes of this article, we'll assume that you know the basics of website design. Instead, we'll just give a few basic pointers on dynamic content and running CGI (common gateway interface) commands.

Designing your own website

Basically, it's up to you whether you use the website we have provided with the WIB or one of your own design. It's just a matter of copying the website you wish to use to the memory card.

When it comes to designing your own site, the best thing to do is to first examine the website we have provided and look at the source. We have used dynamic variables, as well as forms and Javascript.

There are plenty of HTML introductory tutorials on the web. Also, you can use a freeware HTML WYSIWYG (What You See Is What You Get) editor such as ***Kompozer,*** which you can download from **http://kompozer.net**

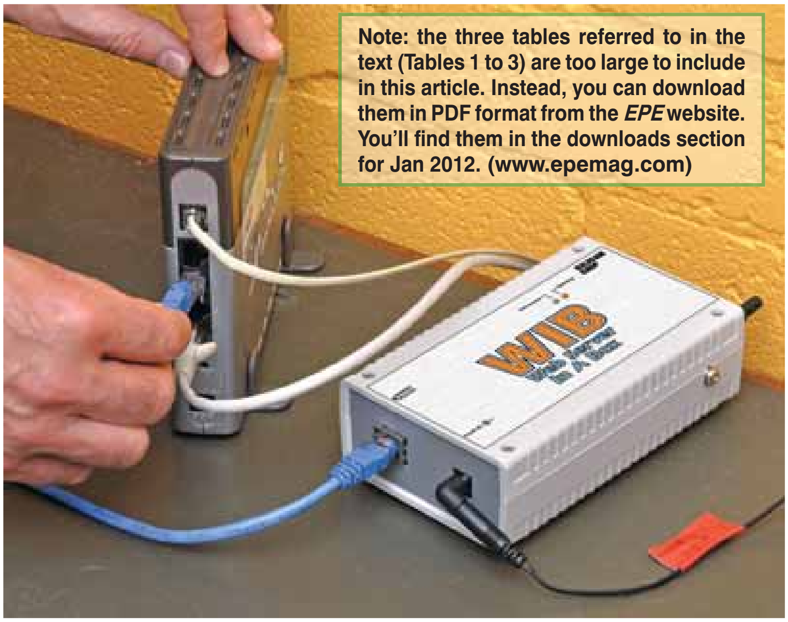
We used ***Kompozer*** to design the website provided with the WIB, and you can change all its important settings if necessary.

Dynamic content

The WIB implements a simple system for dynamic content.

For dynamic pages, a string of the form ~XX, where XX represents a hexadecimal code between 00 and FF, is replaced by the value of that variable. Table 2 on the *EPE* website (**www.epemag.com**) gives a list of the hexadecimal codes and their corresponding variables.

Note that the files which are emailed are also considered dynamic content.



Note: the three tables referred to in the text (Tables 1 to 3) are too large to include in this article. Instead, you can download them in PDF format from the *EPE* website. You'll find them in the downloads section for Jan 2012. (www.epemag.com)

An Example FTP Session . . .

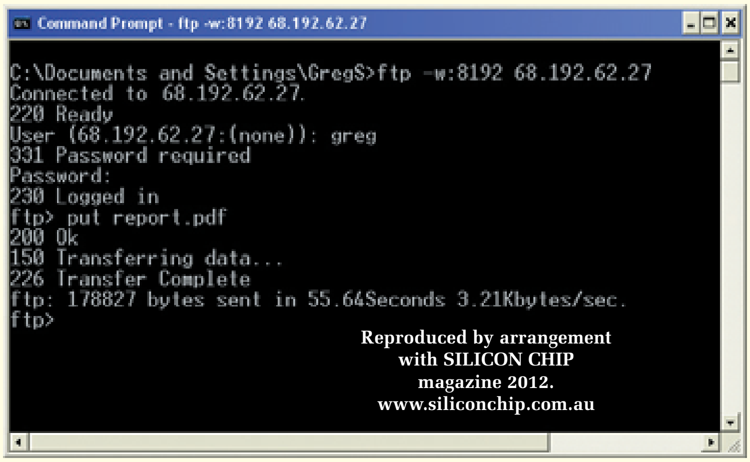


Fig.27: an example FTP session. Here, a file called 'report.pdf' has been been uploaded to the WIB (via the Internet) using the 'put' command.

List of accepted FTP commands

CD	change directory	**MGET**	retrieve a collection of files from the WIB
PWD	show the current directory	**MPUT**	send a collection of files to the Ethernet web server
DELETE	delete a file	**USER**	specify username for login
DIR	show the files in the current directory and the file sizes	**PASS**	specify password for login
LS	show only the name of the files in the current directory	**OPEN**	open an FTP connection to a remote server
PUT	send file to Ethernet web server	**QUIT**	exit the current FTP session
GET	retrieve a file from the WIB		

Fig.27 shows an example FTP session. Here the put command is being used to upload a file called report.pdf to the memory card in the WIB via the local network.

The first step is to connect to the FTP server, and that's done by going to a command prompt and typing:

ftp 192.160.0.34

The WIB's local IP address has been used here, but you would have to substitute the public IP address (or the hostname if you have set up dynamic DNS) if you want to access the WIB via the Internet (as shown in Fig.27).

After that, it's simply a matter of entering the username and password to log on, and then issuing the command:

put report.pdf

The file should then upload to the WIB. If you get an error that says '**Netout: connection reset by peers**', it means that the buffer in the Windows FTP client has overflowed and will have to be increased in size. To do that, quit the current FTP session (using the quit command), then restart it with the command:

ftp-w:8192 192.168.0.34

and try uploading the file again. This will double the buffer size from the default. If you get the same error message, double it again by starting the FTP session using the command:

ftp-w:16384 192.168.0.34

Similarly, if you want to download a file called report.pdf, use the command:

get report.pdf

For example, let's say that we have a dynamically typed file containing the text:

The ~1E is currently ~D0 degrees.

From this, it follows that if the name of Variable 0 is set to 'Temperature' and the current value for the temperature (derived from a temperature sensor connected to the first ADC input) is 26.5, then this would appear as:

The Temperature is currently 26.5 degrees.

As mentioned, any files sent by email, such as ***var0max.txt*** (on a maximum condition in variable #0), can also contain dynamic content. In order to show the ~ character you need to escape it by using the sequence ~~.

For example, ~~02 will translate to ~02, yet ~02 will translate to the Subnet Mask (refer to Table 2).

The default ***var0max.txt*** file contains the following text:

The ~1E is currently at ~D0, which is above the set maximum of ~1C! This is an automatically generated message, created on ~E2.

As before, **~1E** will be replaced by the name of Variable 0, while **~D0** will be replaced by the current value of that variable. **~1C** is replaced by the maximum set value, while **~E2** is the current time, as determined by the SNTP module. In other words, the email would look like this example:

The Temperature is currently at 30.0, which is above the set maximum of 28.0! This is an automatically generated message, created on Fri 28 August 2009 17:00:00.

Therefore, by modifying this file and others like it, you can customise the emails that are sent as notifications.

Running CGI commands from an HTML form

It is possible to execute one of the commands in Table 1 from an HTML form. The commands are of the form:

<command>?<name>=<value>

Any system setting can then be defined using an HTML form by using the **set** command (see Table 1 on the *EPE* website), the name of the variable (Table 2) and the new value, eg:

set?NTPTimezone=0

will modify the time zone for SNTP to UTC time.

An in-depth discussion of HTML forms is beyond the scope of this article, but if you are interested, you should look at the source code for the supplied website. A number of HTML forms are used to change the WIB's settings. By imitating these, you can create complex websites.

Memory card special system files

The are several special system files on the memory card, and these either have a 'txt' extension or a 'dat' extension. For security reasons, these two file extensions should always be set to private in the HTTP Settings (file permissions) – see text. This is the default, but you can change this and open up your system to the public if that's what you really want to do (not recommended!).

You can also modify some of the special system files to customise the behaviour of the WIB. The relevant files are as follows:

log.txt contains a human-readable log of system events since the last reset. It is emailed to the user each time there is a system reset. All important system events are logged, like an incoming FTP connection, a change in the public IP address detected by the dynamic DNS client, and any email sending activities.

settings.txt contains a human-readable list of single line entries that override the system defaults. The user may modify this file to define new default values.

values.dat is used to store system settings in binary form and should not be modified.

test.txt contains the body of the test email sent when the user presses the 'Test Email' button in the supplied website. It is used to test that the SMTP settings are correct.

var0max.txt is the file that is emailed when variable #0 has exceeded its set maximum.

var0min.txt is the file that is emailed when variable #0 is below the set minimum.

var1max.txt, var1min.txt, var2max.txt, var2min.txt, var3max.txt, var3min.txt similar to above but for variables #1, #2 and #3.

var0log.txt is the file that holds the logged values of variable #0. This file is emailed if periodic logging is enabled for that variable.

var1log.txt, var2log.txt, var3log.txt: similar to above but for variables #1, #2 and #3.

The settings.txt file

The default settings can be overridden by a file named **settings.txt.** This file is stored in the root folder of the memory card.

In operation, the firmware loads and parses this file at boot-up (or when there is a Master Reset). Each line should contain a statement of the form:

<setting name> = <value>

where **<setting name>** is one of the settings in Table 2 (provided it's not read only), and **<value>** is the value to set.

For example, to change the (default) gateway to 192.168.0.33 you would have a line in **settings.txt** that reads:

Gateway = 192.168.0.33

This would override the default value, but not the value that was last set through the web interface. Those values are instead stored in a file called **values.dat**, but in binary form.

Note that it is permissible to add any number of spaces before the equals sign for readability. For example, although the IP address settings name is **IPAddress**, you can validly set the IP Address by writing a line in your **settings.txt** file that looks like this:

IP Address = 192.168.0.30

Restoring the defaults

To restore the default values, you can simply delete the file ***values.dat*** and reset the WIB by clicking the ***Master Reset*** button (or reboot the WIB). Alternatively, you can go to the Basic Settings page of the supplied website and click the ***Restore Defaults*** button.

Another option if you are creating your own website is to run the ***defaults*** command from an HTML file (see Table 1).

You can also define the current settings as the defaults by clicking on the ***Create Defaults*** button and then resetting the WIB by clicking the ***Master Reset*** button (in the supplied default website) or by rebooting the WIB (power off and on). ***EPE***

Web Server In a Box

By Mike Hibbett

Alternative SD Card Connector

THE SD-Media connector used in the WIB project is currently unavailable from suppliers, and no identically-sized part has been found. This article describes how another connector can be used.

We have chosen a part manufactured by Multicomp and available from Farnell, part number 9186158, at a price of £1.09 + VAT. (Postal and package charges not included).

As with the original connector, this one has several pins that are unused in this design. The order of the seven pins used is the same, but the spacing differs. A small 'daughter board' PCB has been designed to ease the construction. This small board (31mm × 31.5mm) is available from the *EPE PCB Service*, code 835. If making your own PCB, the clearances are large enough that with care this design could be transferred to PCB by hand using an indelible pen.

Construction

We recommend that assembly is made after the main WIB printed circuit board has been assembled.

Once the daughter board has been etched and thoroughly cleaned, cut it to size as indicated by the corner markers, as shown in Fig.1. It is important that the board is the correct size, otherwise it will interfere with some of the component solder pads on the main PCB.

Next, we need to cut off the two locating pins on the bottom of the connector, as shown in Fig.2. This needs to be done with care, so that the knife doesn't fly off and damage the pins (or your fingers!) With a sharp thin blade, gentle pressure should be sufficient.

To solder the connector to the board, start by tinning one of the large corner pads, as shown in Fig. 1. Then position the connector with the pins correctly aligned to the pads on the board, and lightly solder the pad. Again, check that the pins are correctly aligned; you can reheat the solder joint and move the connector if not.

Once you are happy with the position of the pins, you can solder them down. Ensure the four large pads on the corners of the shell are soldered well, as they provide the main mechanical fixing of the connector to the board and reduce stress on the pins. See Fig.3.

Fixing the daughter board

Mix a small amount of epoxy resin, and apply a thin layer to the bottom of the daughter board and press the daughter board into place, as shown in Fig.4.

With a fine-tip disposable applicator, such as a toothpick, apply a thin layer of epoxy around the edge of the daughter board where it touches the main PCB. Allow to dry thoroughly.

Solder the daughter board pads to the pads on the main PCB using a thin solid wire, as shown in Fig.5. Insulation will not be required. With such short wires it can be difficult to solder and the use of thin tweezers is advised.

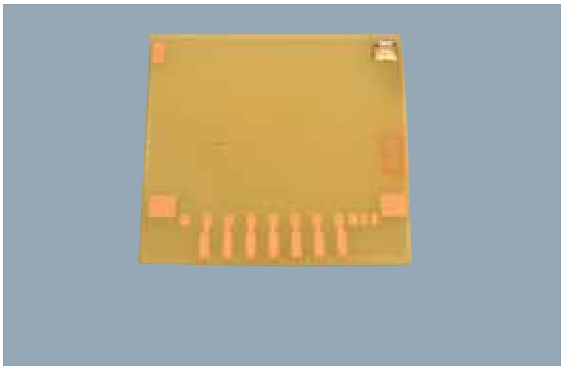


Fig.1. Etched 'daughter' PCB ready for the connector

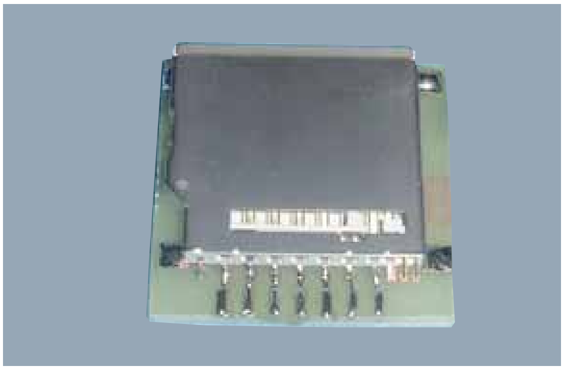


Fig.3. Finished daughter board

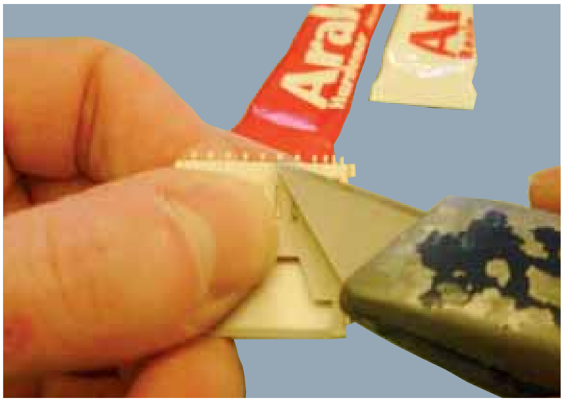


Fig.2. Cutting locator tabs off

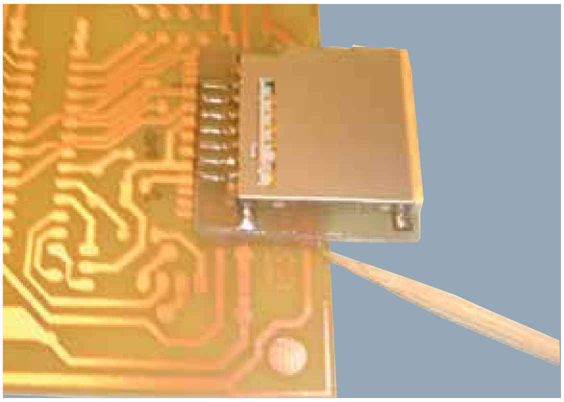


Fig.4. Gluing the boards together

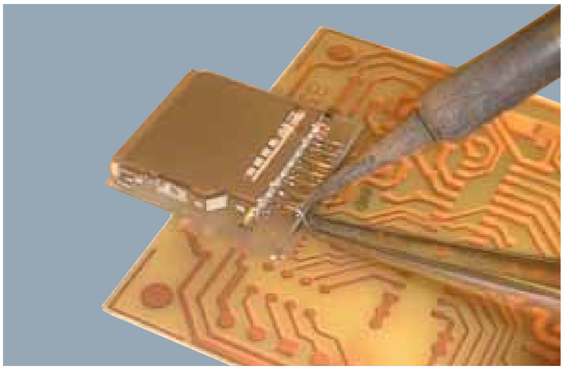


Fig.5. Connecting the two boards

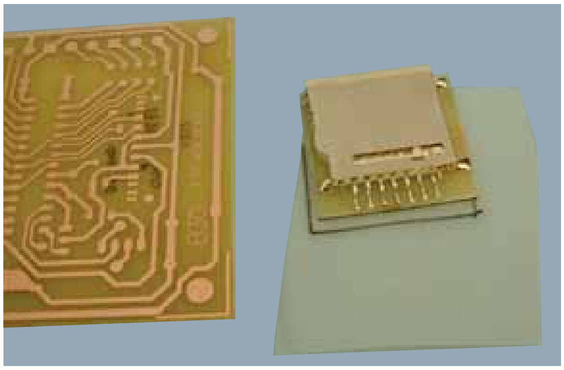


Fig.6. Cut an insulator to size, using a printout of the daughter board (or a real one if you have it, like we did!

Alternative construction

If you feel your soldering skills are sufficient, this connector can be mounted directly onto the main PCB, without the use of a daughter board. To do this, glue a small rectangular sheet of insulating material, such as plastic (a piece cut from a plastic milk carton will suffice) onto the main PCB in the same position as shown in Fig.6 and Fig.7.

Carefully glue the connector into a position so that the pins of the connector are about 5mm back from the pads on the board, and aligned with the pads. The spacing between the pads and the connector pins is not quite the same, but is in the same order. By mounting the connector 5mm back you should have sufficient clearance to use thin un-insulated hook-up wire to solder the seven connections required. It will be fiddly!

Use epoxy resin glue to fix the connector to the plastic; you have to use it sparingly, so that the glue does not leak into the connector itself. Epoxy resin is strong, so the small amount used will be sufficient. This kind of approach is only suitable in this specific project, as the card will be enclosed within the box, and will not be frequently removed!

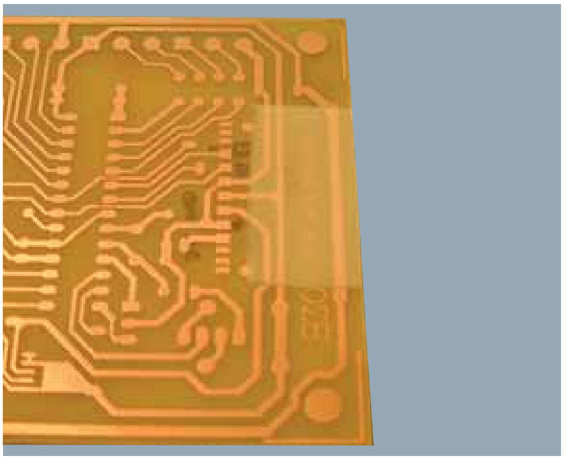


Fig.7. Fitting the insulator

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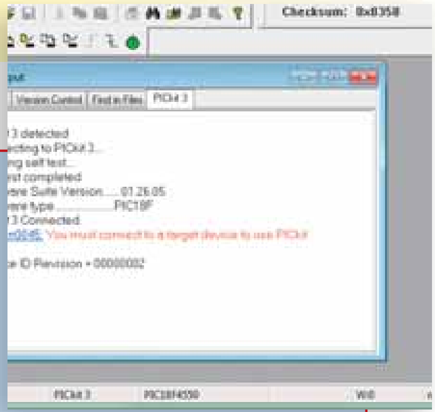


Programming PICs: How It's Done

Many of our projects include a PIC microcontroller as the central component. But how do you program the PIC if you're not buying a kit or if you want to upgrade the firmware to a later version? Here's a step-by-step guide to doing it yourself.

By MAURO GRASSI

FOR MANY electronics enthusiasts, programming the PIC micros that are now used in so many of our projects is something of a mystery. If you buy a kit, it usually doesn't matter, because the micro will be supplied pre-programmed. Alternatively, if you're building a project from scratch, then you've either got to pay someone to do it for you or learn how to do the job yourself.

A similar problem arises if the PIC fails and has to be replaced, or if you want to update the firmware to a later version. It's not uncommon for the firmware to be revised after a project has been released, usually to add extra features, but also sometimes to fix any bugs.

Fortunately, programming PICs is straightforward although you do require a low-cost PIC programmer (more on this shortly). By following the simple steps outlined in this article, you will be able to program almost any Microchip microcontroller, including the popular 16F, 18F, dsPIC33F, PIC24F and PIC32 families.

A few basics

PIC microcontrollers have onboard non-volatile memory (FLASH) that stores the program code (some also have onboard EEPROM for storing persistent data). This program code is referred to as the 'firmware'. The term 'non-volatile' simple means that the firmware remains in memory, even when the power is turned off.

Programming (or reprogramming) can be done in at least two ways: (1) through 'ICSP' (in-circuit serial programming), or (2) through 'RTSP' (run time self-programming). The latter option requires a 'bootloader' program to be running on the target device.

A bootloader is a separate program that can write a new firmware image on to a microcontroller. The firmware image is supplied to the bootloader usually via a USB or serial connection, or from some other storage medium (eg, a memory card).

In most cases, however, a bootloader will not be used. It adds complexity to the code and the bootloader itself needs to be initially programmed. As a result, many micros are programmed using ICSP.

Some projects include the necessary ICSP interface as part of the design (ie, it's incorporated into the PC board). Otherwise, you will need to remove the PIC micro from its socket and program it externally.

What's needed

Assuming you have your target device (ie, the PIC micro), you will need the following: a PIC programmer, a PC with suitable software and a breadboard if your programmer does not have a 'ZIF' (zero insertion force) socket.

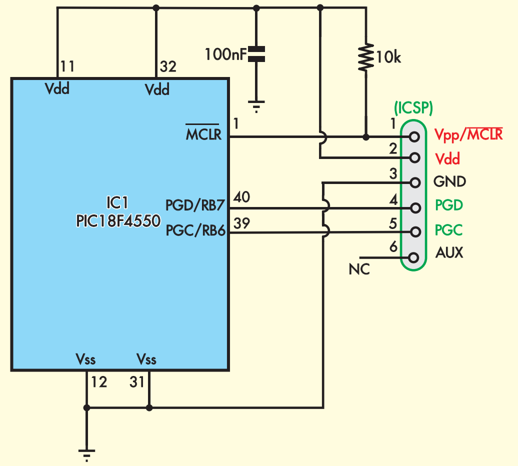
The programmer we recommend to start with is the PICkit 3, which is a low-cost USB programmer (and debugger) from Microchip. There are other more expensive programmers available and they usually have advanced features that the PICkit 3 lacks, such as bulk programming and better debugging options.

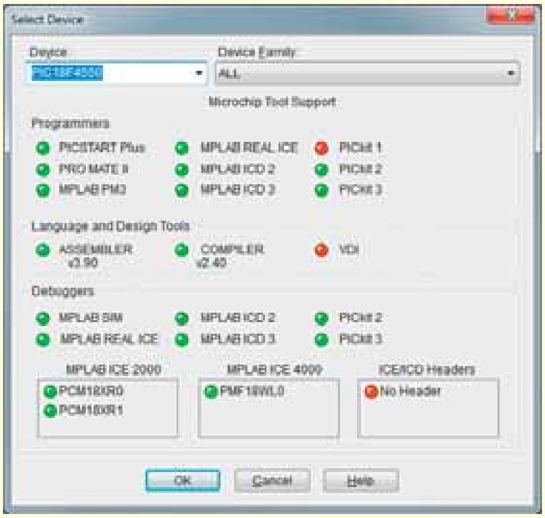
That said, the PICkit 3 is suitable for all hobby work and for prototyping and development. It's portable, inexpensive and can even provide power to your target board (through the USB).

The PICkit 3 can program almost all Microchip microcontrollers, and

Table 1: Programming and power supply connections

Line	Function	Connect To PICkit 3 Line
PGD or PGED	Programming Data Line	Pin 4 (PGD)
PGC or PGEC	Programming Clock Line	Pin 5 (PGC)
$\overline{MCLR}/V_{PP}$	Programming Voltage	Pin 1 ($\overline{MCLR}/V_{PP}$)
V_{DD}	Device Voltage	Pin 2 (V_{DD})
V_{SS}	Device GND	Pin 3 (GND)
AV_{DD}	Analogue Device Voltage	Pin 2 (V_{DD})
AV_{SS}	Analogue Device GND	Pin 3 (GND)





PROGRAMMING EXAMPLE

Fig.1: this diagram shows a typical connection to a PIC18F4550. The pinouts for different devices will vary, and you should consult the relevant data sheet.

Fig.2: this window from MPLAB shows which programmers support a selected device (here, a PIC18F-4550). A green dot indicates that the device is supported.

its firmware can be upgraded to enable support for future devices. The device itself is based on a Microchip microcontroller, and it can update its own internal firmware using RTSP. This is an important feature, because the programming algorithm for a future device may change (different Microchip microcontrollers have different programming requirements).

No ZIF socket

The PICkit 3 does not have a ZIF socket. Instead, you connect its three programming lines, plus two power supply lines to the target PIC. That's five lines in all, and this is simple to breadboard on a prototype board.

The programming lines are PGC, PGD and $\overline{\text{MCLR}}$/V_{PP}. PGC is the clock line, PGD is the data line and $\overline{\text{MCLR}}$/V_{PP} is the reset (Master Clear)/Programming voltage line. Note that these lines are common to all Microchip micros, so if you are using a different programmer, it also will have these lines.

Step-by-step programming

Let's now go through the programming procedure step-by-step. We'll assume that you're using a PICkit 3 programmer and a breadboard.

Step 1 – Making the breadboard adaptor

As mentioned, the PICkit 3 (or equivalent) does not have a ZIF socket, so a breadboard adaptor is used to connect to the target device. The PICkit 3 has six lines (of which five are used) and these can be accessed using a SIL (single in-line) 6-way pinstrip.

In our case, we made a custom PC board to accept this pinstrip (see photos), but it can just as easily be made up on a small piece of stripboard (0.1-inch grid). As shown in the photos, the 6-way pinstrip is soldered to the top of the board.

Two additional pin header strips are then soldered to the underside of the board – one to make the connections between the PICkit 3 programmer and the breadboard and the second to ensure that the assembly is stable when the PICkit 3 is connected.

Step 2 – Making the hardware connections

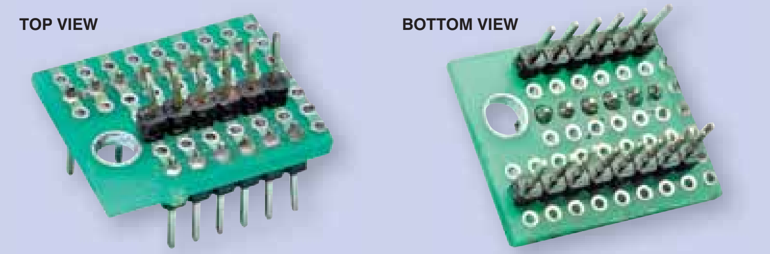
Install the PIC micro (henceforth referred to as the 'target device') on the breadboard, then download its datasheet from the Microchip website.

We are assuming here that you have a DIP (dual in-line package) device. The datasheet contains the pinout information you will need to connect the programmer to the target device. Although there is variation in the pinouts across and within Microchip families, the lines listed in Table 1 (if present) must be connected.

Note that, depending on the device, these lines may be labelled differently. For example, some devices have multiple PGC/PGD pairs, which are then labelled with a numerical suffix (eg, PGED1, PGEC1).

If there is more than one pair, any pair can be used for programming. However, only one can be used for debugging (this is set by writing the configuration words of the microcontroller). We are not going to cover debugging using the PICkit 3 here.

A typical programming connection diagram (ie, device to PICkit 3) is shown in Fig.1. It uses a 10kΩ resistor to pull up the $\overline{\text{MCLR}}$/V_{PP} line to the supply rail V_{DD}, and some 100nF bypass capacitors on the supply lines. Avoid using capacitors on the V_{PP},



A 6-way pin header is required to connect the PICkit 3 to the breadboard. You can make one up on a small scrap of stripboard.

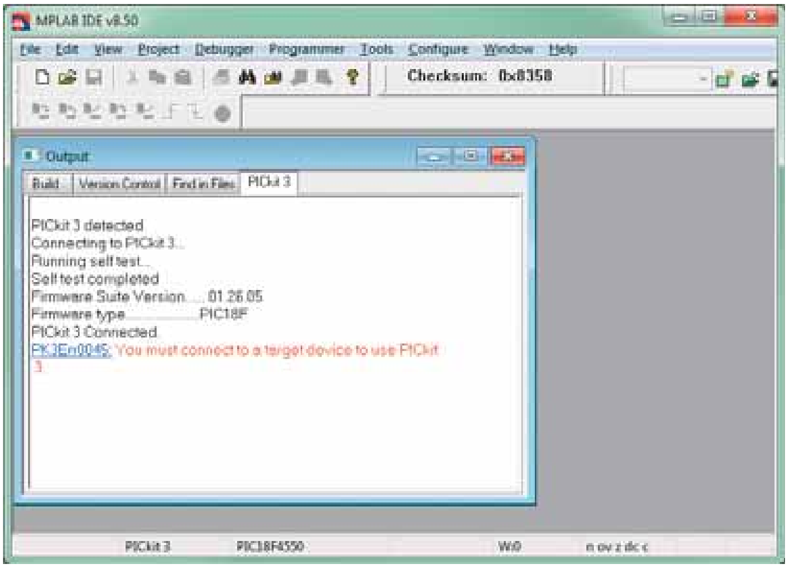


Fig.3: this 'Output' window shows the PICkit 3's startup sequence. The error given means that the PICkit 3 did not recognise any device, in this case because power had not yet been applied.

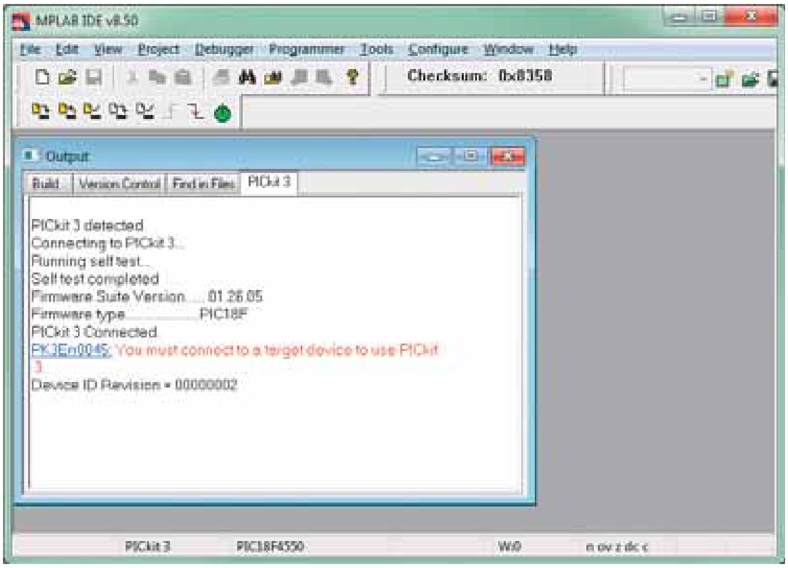


Fig.4: when power is applied to the target device via the PICkit 3, it recognises the device and shows its ID revision number. This also indicates that communication between MPLAB and the target device (via the PICkit 3) is good.

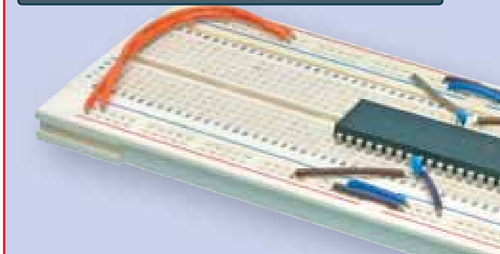
PGC and PGD lines, as these will affect the high-speed digital signalling on these lines.

In addition, the PGC and PGD lines have internal pull downs in the PICkit 3, so don't use pull ups on these lines. As shown in Fig.1, they are connected directly to the PICkit 3.

Note that the supply rail for different microcontrollers will vary. Usually, devices with an 'L' in the part number are low voltage (eg, 18LF1320).

The power for programming can be supplied by the PICkit 3 itself, but you have to enable the power output separately, as described later. For now, it's just a matter of connecting the relevant pins on the target device to the adaptor on the breadboard using wire jumpers.

The **PICkit 3** programmer is available from Microchip Direct – **www.microchip.com/** The catalog number is PG16430) and the price is $US44.95 (£29.50) plus postage.



This photo shows how the PICkit 3 is connected to the breadboard (and to the target device) via a pin header socket.

Note that the PICkit 3 can supply up to 30mA at between 1.8V and 5V to the target device, which should be sufficient for programming (note: this may be insufficient for debugging if using the PICkit 3 as the only power source). Note also that no separate system clock is required for programming – the clock signal supplied by the host (ie, the PICkit 3) via the PGC line is sufficient.

Step 3 – Installing PC software

Suitable PC software is required to drive your programmer. Many programmers are supplied with their own software, while the PICkit 3 uses MPLAB. This IDE (integrated development environment) is free and can be downloaded from the Microchip website at **www.microchip.com**

MPLAB is a 32-bit Windows application, but will also run on 64-bit Windows versions. The screen grabs shown in this article are from MPLAB v8.50. Future versions may be different.

Step 4 – Connecting The PICkit 3

The PICkit 3 connects to your PC using a USB cable (supplied with the programmer). Assuming you have already installed MPLAB, the driver will be found and installed automatically as soon as the PICkit 3 is connected.

Once that is done, you can connect the PICkit 3 to your target device using your breadboard adaptor. Note that Pin 1 of the PICkit 3 is indicated by a white arrow (see photo).

Step 5 – Programming

Once the connections are complete, MPLAB is used for programming via

the PICkit 3 (it can also be used for development and debugging). You will need the new firmware program for the target device and this is usually supplied as an Intel HEX file (extension '.hex'). The programming steps are as follows:

- Start MPLAB, then go to Configure -> Select Device and select the correct device type. For example, if you are programming a PIC18F4550 microcontroller you need to select it here.

  Whether or not PICkit 3 can program your device will be indicated by either a green or yellow dot (see Fig.2). A green dot means that the target device is supported, while a yellow dot means beta (ie, not fully tested) support. A red dot means the device is not currently supported and you won't be able to use the PICkit 3 to program that device.

- If the device is supported, enable the programmer by going to Programmer -> PICkit 3. This will bring up a dialog box similar to Fig.3.

- Enable the PICkit 3 to provide power for your device. To do this, go to Programmer -> Settings, click the Power tab and check that the correct voltage for your target device is indicated in the voltage group box. Usually, MPLAB will set this to the default for the selected device. If there is a range of valid voltages, the lowest will be selected.

  If the voltage is incorrect, change it to the correct value.

  Now click the 'Power Target Circuit from PICkit 3' checkbox to enable the PICkit 3 to power the device and click OK. If all is well, the PICkit 3 will recognise the device, as shown in Fig.4.

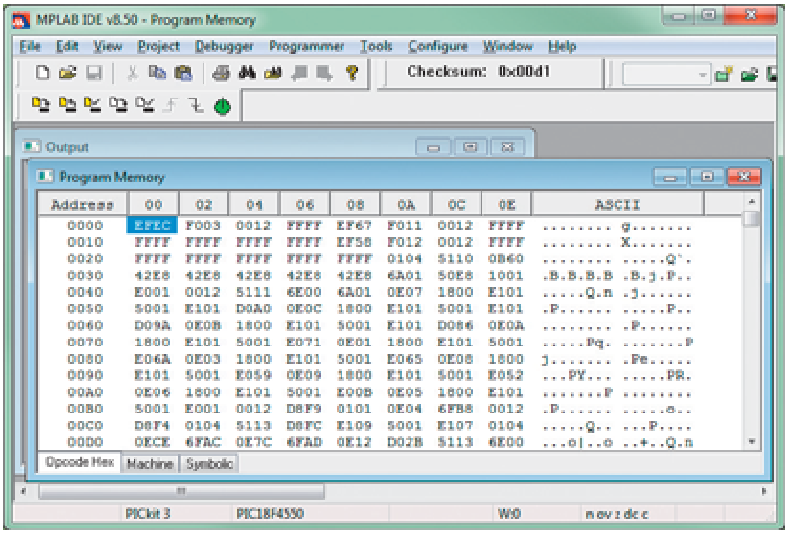


Fig.5: this screen grab from MPLAB shows the contents of the program memory. The HEX file is parsed and the program memory is then loaded with the firmware image.

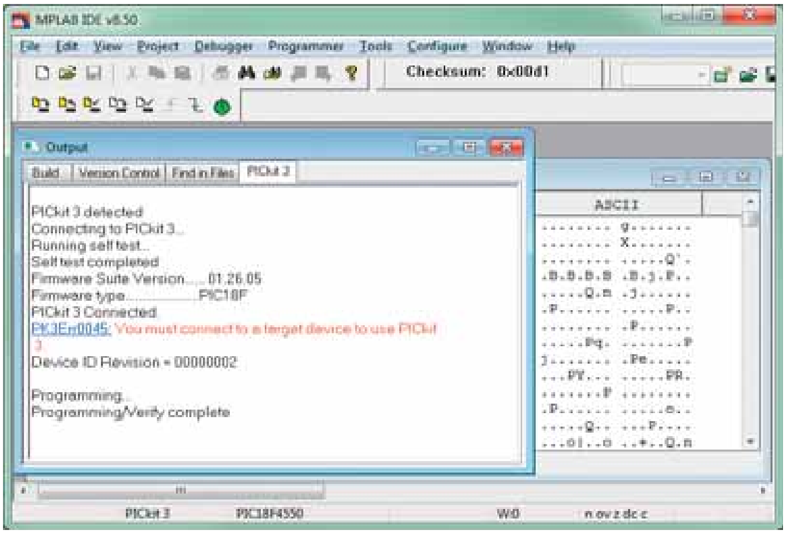


Fig.6: the 'Output' window now shows the result of programming the device, in this case, a PIC18F4550. MPLAB will program and verify the image. The 'Programming/ Verify complete' message indicates all is OK.

Here, the last line shows the Device ID (Silicon) revision, indicating that communication between your PC and the target device (via the PICkit 3) is good.

- Go to File -> Import. An Open File Dialog will appear and select the 'All Load Files' in the Files Type field. This includes the '.hex' file extension.

- Navigate to the new firmware file and open it. MPLAB will now decode the HEX file. You can see the contents of the memory by going to View -> Program Memory, as shown in Fig.5.

- Finally, go to Programmer -> Program to program the HEX file to your target device. MPLAB will erase the device, then program it and finally verify the image. If all goes well, you should see a dialog as shown in Fig.6.

Your device is now programmed and probably running. ***EPE***

Recycle It!

BY JULIAN EDGAR

www.julianedgar.com

Not one but two wind powered devices

Build a low-cost wind-powered LED Flasher – using mostly recycled parts

WIND-POWERED LED FLASHER #2

THE Wind-Powered LED Flasher's rotor spins around a vertical axis, so it doesn't need to pivot into the wind. It uses an X-shaped pattern of timber arms, with cups or dishes mounted on the ends of the arms; these catch the wind.

For the cups, I looked around for anything I had in the workshop and saw some stainless steel dishes I'd picked up from the rubbish tip. You can also use soup spoons, bowls or something similar. Stainless steel is best because it is most durable. I used screws and glue to attach the cups to the wooden arms – don't forget to face the cups all the same way!

The assembly rotates on a bearing made from the upper and lower halves of a video drum. In this respect, it's just like the vertical bearing for the wind generator described last month, but rather than rotate only sufficiently for the assembly to face into the wind, in this design the rotating assembly spins around and around on its bearing.

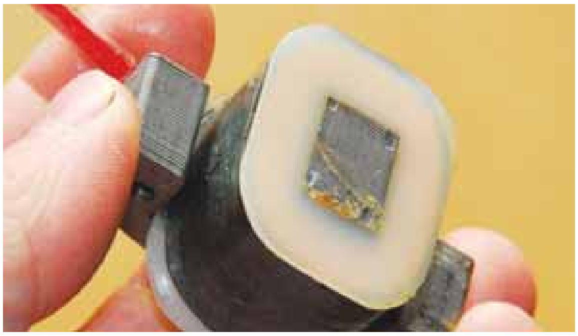
Before you can mount the video drum in this way, you'll need to pull it apart and drill new holes in the two halves for the appropriate mounting screws. The video drum used in this design was taken from a portable VCR and so is rather unusual in shape, but a normal VCR drum could just as easily have been used.

Magnetic power

The electricity to flash the LED is generated by a solenoid drive coil salvaged from a beard or hair trimmer. (If you cannot get

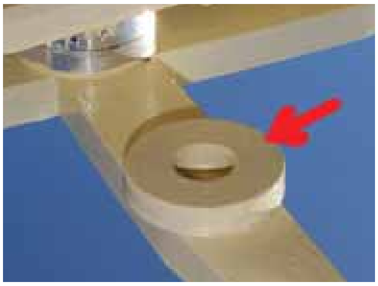
This second project started off as a rotating 'anemometer'. The design worked so well that it was decided to add a flashing light to it. The vertical bearing is from an old VCR, while the 'cups' are stainless steel bowls that I found at the rubbish tip

Here, one of the two magnets has just passed over the iron-cored solenoid coil. Despite the attraction of the magnets and solenoid, the assembly will spin in even the slightest breeze



The solenoid is taken from a salvaged beard or hair trimmer. It is connected to an LED and when a magnet passes, a pulse of current is generated that illuminates the LED

Two magnets are used – both can be salvaged from the magnetron in a microwave oven. (However, *note the safety warning* in main text.) As you can see, the magnets are very strong!



Pictured here is one of the two ex-microwave oven magnets. It is glued with contact adhesive to the timber arm.

a coil from a hair trimmer, you can try a coil from a relay or a solenoid from an old tape recorder or old VCR.) The coil is mounted on an extension piece of timber and is laterally aligned so that it is directly under the magnets spinning past on two of the arms. The coil is vertically positioned so that the magnets just clear it as they move past.

For the magnets, I initially tried the very powerful type salvaged from a PC hard drive. However, far better results were achieved by using circular magnets salvaged from an old microwave oven. **Note: You must know what you are doing before disassembling a microwave oven. The high voltage capacitor can KILL you!** Each microwave magnetron contains the two circular magnets you need.

The solenoid can be seen here at right, mounted with two 'saddle' clamps. The lower part of the video drum is at left – this part contains the bearings and these are shielded from the weather when the top section is put in place

Balance check

The magnets were glued to opposing arms using contact adhesive. Rather than glue, I initially tried using flat washers and screws, but the strength of the magnetic field was diminished by the steel washer. If you use just a single magnet, attach a balance weight to the opposite arm. Check the balance by holding the bearing horizontally: the rotating assembly should not exhibit any tendency to always have one arm facing downwards.

High intensity LED

A high intensity 10mm yellow LED was used and was wired straight to the solenoid drive coil. If you have a 'scope or a very fast response multimeter, you could try selecting a dropper resistor to match the peak current to the LED. I didn't bother – it seems to work fine!

Because the steel laminations in the solenoid will rust when exposed, I brushed the whole assembly with two thick coats of paint.

Unlike the Wind-Powered Beacon project (last month), where the light needs to be mounted on the wind generator, with this project you can run a relatively long wire to the LED mounted remotely from the spinning assembly.

Rat It Before You Chuck It!

Whenever you throw away an old TV (or VCR or washing machine or dishwasher or printer) do you always think that surely there must be some good salvageable components inside? Well, this column is for you! (And it's also for people without a lot of dough.) Each month, we'll use bits and pieces sourced from discards, sometimes in mini-projects and other times as an ideas smorgasbord.

And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you have a use for the high-quality bearings from VCR heads. Or perhaps you've found how the guts of a cassette player can be easily turned into a metal detector. (Well, we made the last one up, but you get the idea . . .)

So, if you have some practical ideas, do write in and tell us!

PERFORMANCE

Project #1 (that's the wind generator with model aircraft propeller and the frosted glass light beacon – last month) needs a decent breeze to really get it going. However, what prompted the project in the first place was my move to an area so windy that a large scale commercial wind farms is just up the road! At speeds I'd estimate at over about 15 km/h it starts to illuminate the beacon, and in higher wind speeds it glows very brightly.

On the other hand, Project #2 (wind-powered flasher – this month) will work in even a faint breeze – say anything above 5 km/h. I have the high intensity LED aimed at my kitchen window from about 10 metres away and at night it is oddly disconcerting to see the regular bright flash coming from the garden – especially when you think that there are no batteries, no flashing circuit and no control system!

Max's Cool Beans

By Max The Magnificent

The most amazing iPad game

Based on the fact that I've been waffling on about my iPad 2 for the past couple of months, you are probably aware that I really like this little rascal. In a way, I regret not purchasing an iPad as soon as the first one came out, but things usually work out for the best, and I'm really happy I have an iPad 2 rather than the original version.

In my earlier columns, I've focused on professional applications like iCircuit and Notes Plus. Generally speaking, I'm really not much of a computer games player. Having said this, I'm prepared to make an exception in the case of an incredible creation called Machinarium (**http://machinarium.net**)

This little beauty was created over a period of three years by seven Czech developers, who financed the project with their own savings. It appeared in the iPad 2 App Store in September 2011 (note that the original iPad isn't powerful enough to run this game).

Machinarium commences outside a Steampunk-like city, which – as we are soon to discover – is populated by mechanical and robotic creatures of all shapes and sizes. All I can say is that the graphics and sound effects are simply amazing. Every new scene is a visual delight that is rich with intricate details, including areas of motion like dripping oil and flowing liquids and small mechanical 'creatures' and suchlike.

The goal is to solve a series of puzzles and brain teasers using a little robot called Josef. Our first task is to trick a robot guard in a tower to lower a drawbridge and let Josef into the city. We control Josef by pointing at places and dragging and dropping objects. The first puzzles are relatively easy. I'm sure this is to teach us and to encourage us to go further … but it may be to lull us into a false sense of security.

I say this because I've only just solved an incredibly convoluted task. In one scene we come across a robot band comprising a drummer, a saxophone player, and a robot in charge of a 'big pipe thingy'. Initially, the saxophone player doesn't have any keys, the drummer doesn't have a drum, and there's some sort of critter living in the 'big pipe thingy'. Fixing the saxophone and locating something for the drummer to play didn't take too long … but getting that critter out of the 'big pipe thingy' was a real pain.

The scary thing is that I've been playing this for days, but I think I've only begun to scratch the surface of what's there. The bottom line is that, for only $4.95, this game is an absolute bargain. It will keep you engrossed for hours (weeks in my case) and it would be something fun to do with your friends and family.

Tablets from yesteryear

When I was younger, I really wasn't very interested in history, but as the sands of time have worked their way through the hourglass – and as I've started to become an antique in my own right – I have increasingly found myself drawn to the things of yesteryear.

With regard to storing data, for example, I happen to have two tablet devices with me in my office. One is my iPad 2 tablet computer that is pretty much state-of-the-art for today – the other is a clay tablet that was considered state-of-the-art 4200 years ago.

The ancient Sumerian civilization, which spanned thousands of years from around 5300 BC to 2900 BC, was located in the southern part of Mesopotamia, a little north of what we now know as the Persian Gulf. One of the earliest known forms of written expression is cuneiform script, which emerged in Sumer around the 30th century BC. Cuneiform writing was created by pressing the symbols into soft clay with the slanted edge of a stylus (possibly a stick or a bone or a reed). The tablets were later fired to make them rock-hard. Cuneiform was not a written language like English – instead, it was a picture-writing system that used symbols, similar to Egyptian hieroglyphics or the Chinese system of ideographs.

My small terracotta tablet (only 1¾ × 1½ inches) has lines of cuneiform inscriptions on both sides. It is incredible to me to know that I'm holding something that was created 2200BC (this was around the same time that the first stones were being erected at Stonehenge in England – give or take a few hundred years).

I cannot describe what it feels like to hold this tablet – it literally sends shivers down my spine. I also cannot but help wondering who created it and for what purpose. And, of course, I have to wonder what it says. I tried using the Google Goggles app on my Android smartphone in the vague hope that this would translate the tablet for me, but the app decided that I was holding a small cake, so that wasn't much help.

Maybe one day I will discover what this writing means. I suppose there's a chance it contains an interesting mathematical theory or some deep philosophical musings – more likely it's something a little more mundane, like a laundry list ('Three pairs of socks, two pairs of underwear, not too heavy on the starch'). I really don't care – I just love knowing that someone created something that can 'talk' to me over thousands and thousands of years. You can bet that my iPad 2 tablet won't last nearly as long.

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M02/12

INTERFACE

By Robert Penfold

Analogue-to-digital conversion

RECENT *Interface* articles have covered simple PC input and output ports based on virtual serial interface chips, and analogue converters based on inexpensive industry standard chips.

In theory, bringing these basic building blocks together should provide a PC with simple but effective 8-bit analogue input and output ports. Using them to produce an analogue output is indeed very simple, and it is just a matter of using the latching outputs lines of the output port to drive the digital inputs of the digital-to-analogue (D/A) converter circuit.

In a real-world application, it will often be necessary to provide some additional supply lines, but no handshaking or additional control logic is normally required. New values are output at an appropriate rate, and the converter duly obliges with the appropriate series of output potentials.

In sync

Things are not quite as straightforward with analogue-to-digital conversion, where the reading of the port must be synchronised to the arrival of fresh data from the converter. Otherwise, there is a risk that data will be read while the data on the outputs of the converter is changing, which would give erroneous readings.

One way of achieving synchronisation is to have the converter circuit controlled via an output port of the computer. In the past, when providing a computer with a number of input and output lines was relatively easy, this was the normal approach to the problem.

Fig.1 shows the basic converter circuit for an ADC0804LCN, which will not be considered in detail here as it has been described in previous *Interface* articles. Resistor R1 and capacitor C1 are the timing components for the built-in clock oscillator. Lines D0 to D7 are the data bus and they can be connected directly to the data bus of the input port.

The +5V supply can be obtained from the USB port used with the virtual serial interface. Using the configuration shown in Fig.1, the input voltage range is 0V to +5V, and the converter is a linear type.

Time for conversion

The ADC0804LCN was originally intended for use with the buses of an 8080 series microprocessor, but it can also be used quite easily with circuits that are not based on a microprocessor. The control inputs of the converter can instead be operated by lines of an output port.

The chip select input (pin 1) is not required in a non-microprocessor application, and the device is permanently enabled by connecting this pin to the 0V supply rail. In order to start a conversion the $\overline{\text{WR}}$ (write) input at pin 3 is pulsed low, and the $\overline{\text{INTR}}$ (interrupt) output at pin 5 then goes low when the conversion is complete.

This output could be monitored by an input line of the computer, with the port being read when a low state is detected. The obvious problem with this method is that it requires a digital input to monitor the end-of-conversion output, but all eight inputs of the virtual serial interface are required for the data inputs.

In practice, this problem could be overcome by having a software routine that generates a pulse on pin 3 to start a conversion, and which then waits an appropriate time before reading the input port. In many applications, the conversion time is much shorter than the interval between conversions, making it easy to implement this system reliably.

Analogue-to-digital interface

Things can be taken a stage further, with the need for an output port being removed as well. The converter circuit can have its own control logic rather than relying on the computer to perform this function. This is the approach used in the circuit of Fig.2, which uses a UM245R module to provide the virtual serial port and the parallel to serial conversion. A circuit based on an FT245RL chip could be used instead, as described in previous *Interface* articles, but the UM245R module is much easier to use than the tiny FT245RL surface-mount chip.

The module should be set for bus-powered operation by having the jumper in place on the J2 terminals. It should also be set for operation at normal 5V logic levels, which means having a jumper on pins 2 and 3 of J1. These should be the default settings, but as always with this type of thing, it is advisable to check that everything is as expected.

The USB connector is part of the module and it can be connected to the USB port of a PC using an ordinary A-B USB lead of the type used with printers and scanners.

IC1 is the ADC0804LCN converter chip, and capacitor C1 plus resistor R1 are the timing components for its built-in clock oscillator. The circuit, as a whole, is only designed to provide a few readings per second, and the specified values for C1 and R1 have, therefore, been selected for

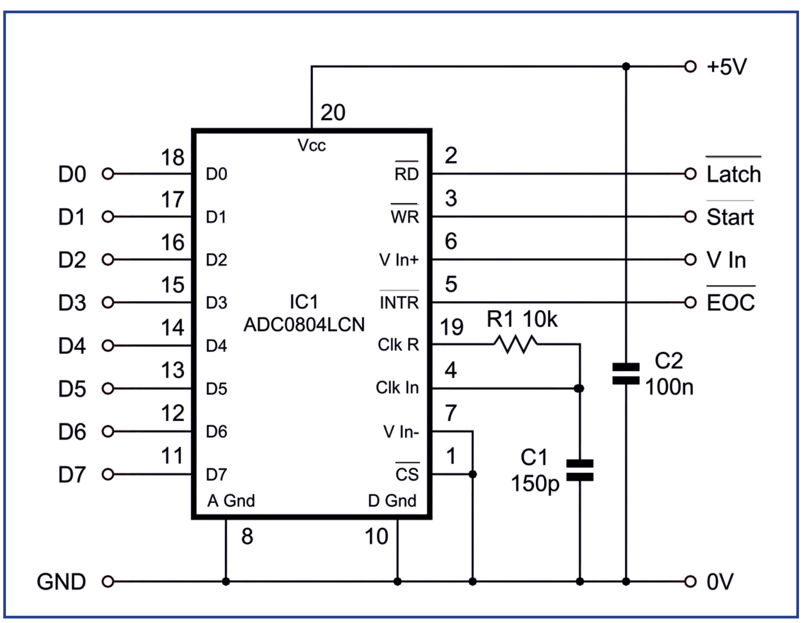

Fig.1. The basic circuit for an analogue-to-digital converter based on an ADC0804LCN chip. It is possible for the computer to effectively provide the control logic if there are sufficient input and output lines available

reliability, rather than the highest possible conversion rate. The data buses of IC1 and the UM245R module are connected directly together. The RD (read) input of the UM245R module is connected to the +5V supply rail, which prevents the bidirectional data bus from going into the output mode. This removes the risk of any conflicts with the UM245R and IC1 simultaneously outputting data on the data bus.

frequency would be increased to about 32Hz with a 22nF component used for C3. There is not much point in going any higher in frequency in applications where the software will need to do nothing more than provide a digital readout and (or) a simple analogue display. This would increase the loading on the computer and would not improve the performance of the onscreen readout.

When interfaced to a microprocessor the output at pin 5 of the ADC0804LCN is used to generate an interrupt each time new data becomes available, and a software routine then services the interrupt and processes the data.

Things actually operate in a similar fashion here, but the interrupts are generated in an indirect fashion. Data is transmitted via the UM245R's virtual serial interface when a con-

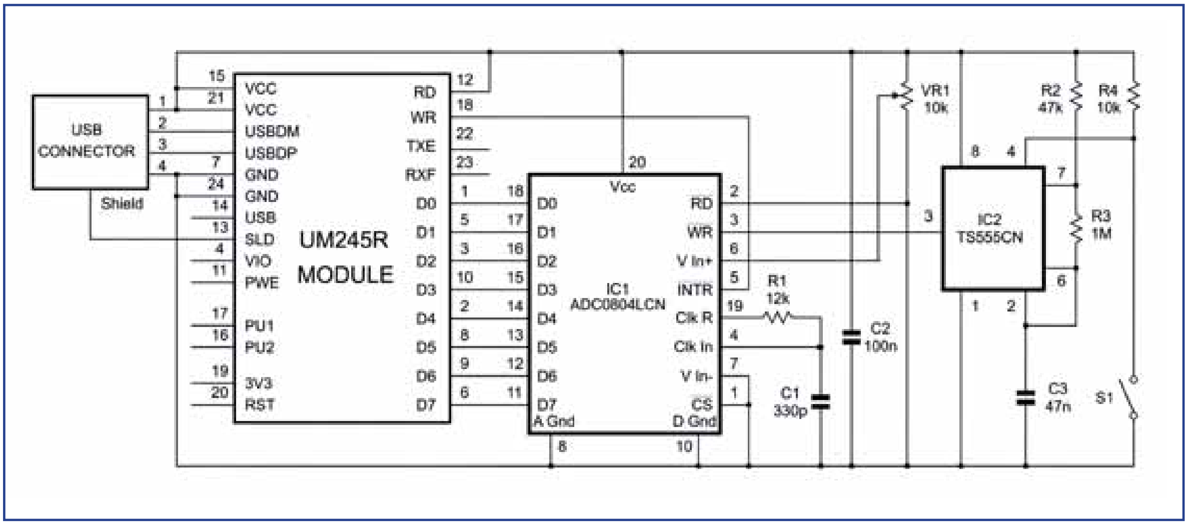

Fig.2. The circuit diagram for an analogue-to-digital converter that interfaces to the computer via a UM245R module and a USB port. An oscillator based on 555 timer chip IC2 is the only control logic that is required.

There is also a $\overline{\text{RD}}$ (read) input at pin 2 of the ADC0804LCN converter chip. Some data sheets for this device seem to suggest that it must be taken low to latch new data onto the data bus and activate the data bus outputs. Other data sheets indicate that this output can simply be connected to the 0V supply rail in non-microprocessor applications, and that the latest conversion will then be latched onto the data outputs as soon as it becomes available. It works properly either way, so the simpler solution of connecting pin 2 to the 0V supply rail is the one that is used here.

Control logic

The control logic is just a simple low frequency oscillator based on 555 timer device IC2, which drives pin 3 of IC1 and starts a new conversion on each high-to-low output transition. A low power version of the 555 was used for IC2, but the circuit should work equally well using the standard device or any other low-power version. Resistors R2, R3 and capacitor C3 are the timing components, and the specified values give an output frequency of about 15Hz with a (more or less) square-wave output signal.

The output frequency/sampling rate is inversely proportional to the value of C3, and it can be increased by reducing the value of this component. For example, the output

Interrupting

A high-to-low transition is needed at the WR (write) input of the UM245R module in order to send the new data each time a conversion is completed. This is achieved by using the signal at the interrupt output (pin 5) of IC1, which goes low to indicate that a conversion has been completed. It is automatically reset to the high state each time a new conversion is initiated.

version ends, and the fresh byte of data is detected by the driver software at the computer. It then generates an interrupt and the new byte of data is read by the application program running on the computer. Of course, this is all handled in the background when using a high level language such as Visual BASIC Express 2010. The program only has to open the appropriate port and then

Listing 1

```
Imports System
Imports System.IO.Ports

Public Class Form1
   Dim WithEvents port As SerialPort = New _
    System.IO.Ports.SerialPort("COM8", 9600, Parity.None, 8, StopBits.One)

   Private Sub Form1_Load(ByVal sender As Object, ByVal e As _
                     System.EventArgs) Handles Me.Load
      CheckForIllegalCrossThreadCalls = False
      If port.IsOpen = False Then port.Open()
   End Sub

   Private Sub port_DataReceived(ByVal sender As Object, ByVal e As _
    System.IO.Ports.SerialDataReceivedEventArgs) Handles port.DataReceived
      TextBox1.Text = (port.ReadByte)
      If port.ReadExisting.Length = 0 Then
      End If
   End Sub
End Class
```

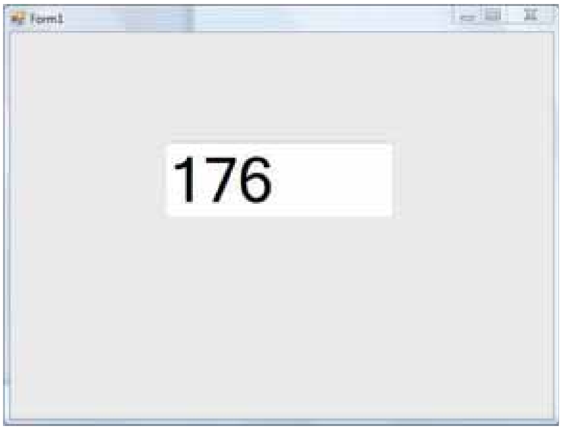

Fig.3. A TextBox component is used to display the last value received from the analogue interface. In a practical application, the raw values will usually require some simple mathematical manipulation before they are displayed

tell the computer how to handle the received bytes of data. Although there is no form of handshaking between the computer and the interface, with this method there is no risk of data bytes being missed or read multiple times.

It is advisable not to have the interface outputting data unless the program that will process the data is 'up and running', and preventing a build-up of data in the received data buffer. Switch S1 effectively operates as an on/off control, and the oscillator is blocked when S1 is closed. Resistor R4 pulls pin 4 of IC2 to the +5V supply level when S1 is opened, and the oscillator then functions normally with readings then being taken and transmitted at the appropriate rate.

Potentiometer VR1 is used to provide a variable input voltage for test purposes, and it should preferably be a linear type. If the interface is performing correctly, it should be possible to take readings from 0, with VR1's wiper at the bottom of its track, to 255 with the wiper at the opposite end of the track, in increments of one. Of course, in a real-world application something such as a sensor circuit would be used to provide the input signal at pin 6 of IC1.

Software

It is possible that Windows will automatically install the correct driver software when the interface is connected to the PC for the first time. If not, it must be downloaded from the FTDI website (**www.ftdichip.com**), and installed in accordance with their instructions. Once the driver software has been installed, use the Windows Device Manager to check that it has been installed correctly, and then make a note of the port (COM) number assigned to the interface.

The simple program of Listing 1 is all that is needed to read data from the analogue interface and display it on the screen. This program is in Visual BASIC Express 2010, which is still available as a free download from the Microsoft website.

The program requires the SerialPort component and a TextBox component to be added to the form. The program uses serial port COM8 because this was the port number assigned to the UM245R module by the operating system on my PC. Where appropriate, this must be changed to suit the actual port in use. The baud rate is set at 9600, which is more than adequate for the low rate of data transfer involved here.

The program simply displays the last received value via the TextBox component (see Fig.3). It uses the ReadByte method, so there is no need for any ASCII conversion or anything of that ilk. In a practical application, it would probably be necessary to apply a small amount of processing to the raw values in order to give a readout in volts, ohms, degrees Celsius, or whatever.

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Digital waveform generation – 2

LAST month, we looked at a circuit, posted to the *EPE Chat Zone* by contributor ***Agustín Tomás***, which attempted to generate sinewaves digitally. Agustín described the circuit as follows:

Shift register driven by a 12x clock. The six outputs loaded with weighted resistors to produce a sine-like waveform.

Network output fed, via a unity gain buffer, to a six-pole LP Butterworth active filter, designed (FilterLab) for f_c=1150Hz.

My intention is to use a sinewave between 10Hz and 1kHz.

The circuit suffered from the problem that although it could generate good smooth sinewaves at the upper end of its frequency range, at lower frequencies, the output was unacceptably step-like. We explained the circuit operation in detail, discussed its simulation and explained why in general terms it failed to function as hoped. This month, we will look at the principles of creating waveforms from digital data in more detail

The basic structure of the circuit discussed last month is shown in Fig.1. The implementation we looked at was elegantly minimal: the sequence generator was a Johnson counter; and the digital-to-analogue converter (DAC) was just some carefully chosen resistors and a unity gain op amp buffer. The same principle could also be implemented in a more sophisticated way, where the sequence generator would be a full binary counter connected to a memory chip containing sine function values, and the DAC would be a full DAC chip. Such a circuit could generate waveforms of any shape by storing appropriate data values in the memory.

Digital generation

The circuit in Fig.1 is not the best approach for digital generation of waveforms. However, it is straightforward to understand and will suffice for our discussion of concepts this month. Next month, we will look at more sophisticated approaches and practical implementation.

The circuit in Fig.1 operates by passing a sequence of numbers to

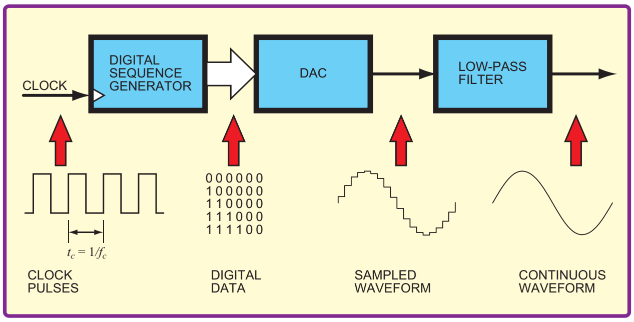

Fig.1. Block diagram of a circuit for digitally generating waveforms

the DAC, which converts them to a corresponding analogue voltage. These numbers are referred to as *samples*, and represent the amplitude of the waveform at particular instances of time.

Typically, the time points are evenly spaced at the sample interval t_s, which gives us *sampling frequency* $f_s = 1/t_s$. Assuming the digital code updates with clock cycle, the sampling frequency in Fig.1 is equal to the clock frequency $f_s = f_c$.

Fig.2 shows an analogue waveform, *V(signal)* and sampled versions of it. The middle waveform in Fig.2, *V(sample)*, shows the waveform sampled at 2kHz (sampled interval 500μs). The narrow pulses (which ideally would have zero width) are referred to as *impulses*, and represent the pure digital data values at the instant of the sample points. Impulses are important in sampling theory and other areas of mathematics.

Hold on

The impulse train in this middle waveform is not really practical, and in a real circuit the sample values are

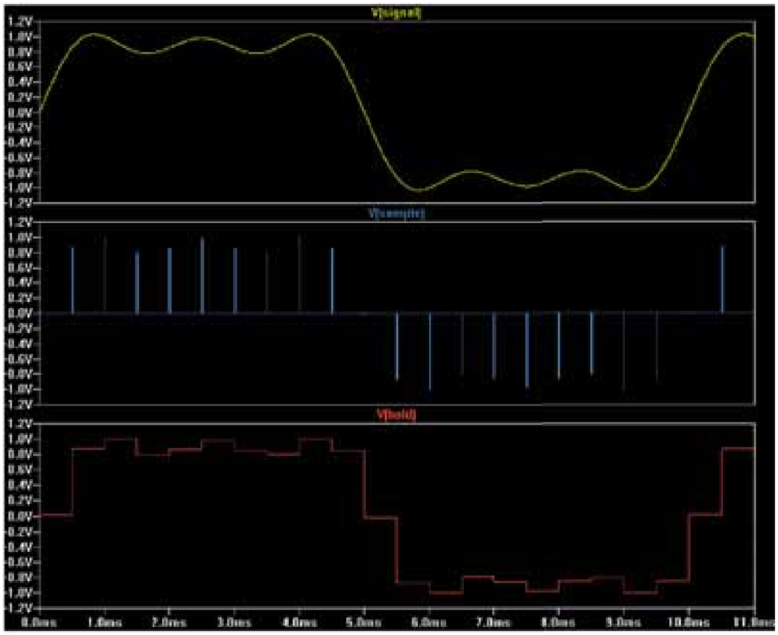

Fig.2. A continuous waveform, a sampled waveform and a sampled-and-held waveform

typically held constant between the sample points to give a step-like signal, as shown in the bottom waveform of Fig.2. Holding the samples like this is referred to as *zero-order hold*. In contrast, for example, a first-order hold would join the sample values with straight lines sloping from point-to-point (also known as a piecewise linear approximation).

This example signal is obviously not a sinewave – remember, the circuit in Fig.1 can generate any wave shape, so it is worth looking at a more complex case. We can study the spectrum of the signals concerned, which is a plot of signal amplitude against frequency.

A sinewave has a spectrum which contains just one frequency, but other waveforms have more complex frequency content. The continuous analogue signal in the first waveform in Fig.2 contains frequencies of 100Hz, 300Hz and 500Hz. The spectrum is shown in Fig.3

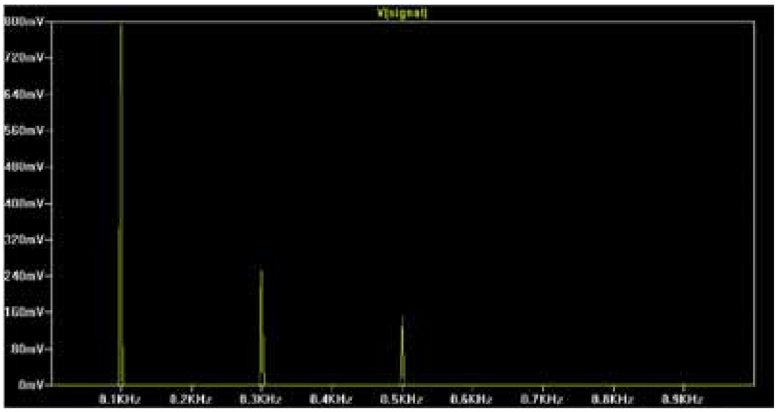

Fig.3. Spectrum of the first waveform in Fig.2

A problem with the approach shown in Fig.1 is that in order to change the frequency of the output waveform, f_o, it is necessary to change the clock frequency, f_c, of the digital sequence generator. If the frequency generator goes through n steps for the complete output waveform cycle we have:

$$f_o = f_c/n$$

This is undesirable because we need to obtain the clock from an oscillator with a wide frequency range (assuming we want a wide output frequency range). However, most digital circuits use a fixed clock or have limited variability or frequency options. Building a wide-range oscillator with accurate frequency control requires a reasonably complex circuit, and is certainly more difficult than generating a single fixed frequency, which is readily (and very accurately) achieved using a crystal oscillator. Next month, we will look at how to overcome this.

Filtering problems

The variable clock frequency also leads to difficulties with filtering the waveform. The output from the DAC in Fig.1 is a sampled analogue signal. This means that it does not vary continuously with time, but takes on a new value only at the sampling frequency.

To convert a sampled analogue signal into a continuous signal, it is necessary to low-pass filter it. In simple terms, the filter (known as a *reconstruction filter*) 'smoothes out' the jagged sampled waveform to give the required output signal.

However, this simple view is insufficient to determine exactly what filtering is required. It is helpful to look at the signal in the frequency domain (spectrum) to understand the filtering requirements. Last month, we saw that the filter in Agustín's circuit (which has a fixed cut-off frequency) was able to filter the unwanted spectral components from the higher frequency digital sinewaves, but as the clock frequency is reduced, more of the unwanted frequencies fall within the pass-band of the filter, resulting in a poor output sinewave. However, last month we did not go into full details of where these unwanted frequencies really came from.

Nyquist criteria

There is a significant body of theory and mathematics relating to sampled analogue signals. Of particular importance in this context are the *Nyquist Criteria*, *Nyquist Rate* and *Nyquist Frequency*. There is some variation on exactly how these terms get used, so take care if reading further about this.

The Nyquist Criteria states that the sampling frequency used to digitise an analogue waveform must be at least twice the highest frequency present in the signal. This sampling rate is known as the Nyquist Rate. If a waveform containing frequencies above the Nyquist rate is sampled, then errors, known as *aliasing*, will occur when we attempt to reconstruct the original signal.

It is impossible for a sampled waveform to contain information about frequencies above half the sampling frequency. However, if these frequencies are present in an input being sampled, they must have some influence on what happens and, therefore, their frequencies will be misinterpreted in the sampled data (hence the name 'aliasing'). A well known everyday example of this is when the wheel of a vehicle appears to be moving at the wrong speed or direction in a video (known as the 'wagon wheel' effect).

Having said all this, we now have to point out that this should not be an issue here, because our digital data (from the sequence generator is Fig.1) represents an ideal waveform created mathematically, rather than obtained by a sampling process. We can have, by design, a 'perfect' sampled waveform, which we could reconstruct perfectly if the performance of our DAC and filter is good enough. In practice,

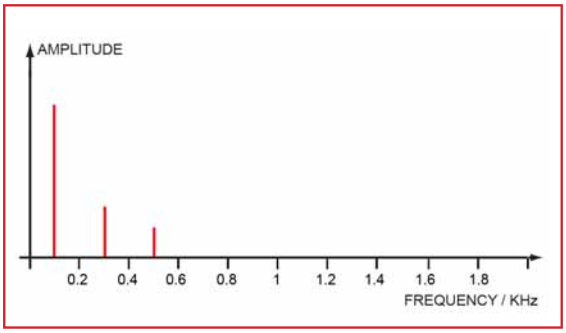

Fig.4. Spectrum of required analogue signal (schematic version of Fig.3)

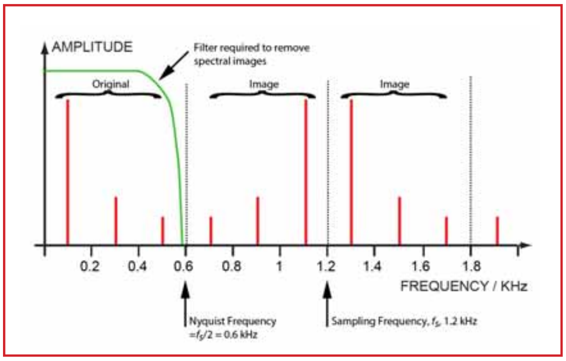

Fig.5. Spectrum of sampled analogue signal (impulse train)

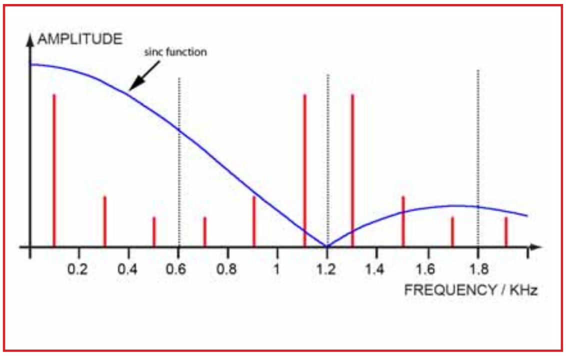

Fig.7. Spectrum of sampled analogue signal showing sinc function. The amplitudes of the frequency components in the sampled waveform are scaled by the sinc function in the sampled-and-held waveform (see Fig.7)

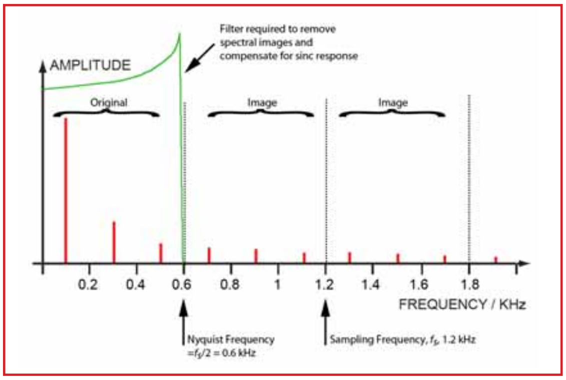

Fig.7. Spectrum of sampled-and-held waveform. The filter has to remove the unwanted image frequencies and compensate for distortion of the wanted signal, the sinc function (Fig.6)

of course, the limited number of bits in the DAC and non-ideal filter characteristics will limit the quality of our output waveform.

The Nyquist Frequency is equal to half the sample rate and relates to reconstruction of a sampled waveform into a continuous analogue signal. In order to properly reconstruct (or generate) a sampled waveform from the sample data, we need a filter which will remove all frequencies above the Nyquist Frequency. This is best explained with reference to some example spectra.

Fig.4 shows the spectrum of a signal, which we will assume we have stored in sampled form and wish to reconstruct or generate into a continuous analogue signal using the circuit in Fig.1, or something similar. This spectrum is, in fact, a schematic version of the simulated spectrum in Fig.3, so the output analogue waveform should be like the top trace in Fig.2.

Impulse train

The impulse train version of the sampled waveform from Fig.4 has the spectrum shown in Fig.5 (this does not correspond exactly with Fig.2 as the sample rates are different). The spectrum is obviously different from Fig.4, but closely related to it.

We might expect the spectra to be different because the waveforms certainly look different (top and middle trace in Fig.2). The spectrum in Fig.5 contains multiple copies, or images, of the spectrum in Fig.4 shifted in frequency and in some case reversed (mirrored).

There is a spectral image either side of each multiple of the sample frequency (f_s, $2f_s$, $3f_s$ and so on), although only the images relating to f_s are shown on Fig.5. The image to the right (higher frequency) of each multiple of f_s is simply a shifted copy of the original, whereas the one to the left (lower frequency) is both shifted and reversed. They are like mirror images about the sample frequency (and multiples thereof). This is like the upper and lower sidebands that occur in AM radio.

A low-pass filter is required to remove all the images from the spectrum of the impulse train and obtain the original signal. The required filter response is shown in Fig.5. Such a filter will remove all frequencies above about 600Hz from the spectrum in Fig.5, resulting in a spectrum like that in Fig.4.

Sampling

A full explanation of why the spectrum of the sampled signal contains images requires a mathematical analysis of the sampling process. Sampling is represented mathematically as the multiplication of the original signal by an infinite waveform of unit impulses (sometimes called a *Dirac Comb* or *Shah Function*), in which the unit impulses are separated in time by the sampling interval.

The unit impulse train has a spectrum which looks similar to its waveform when plotted on a logarithmic frequency scale. It has unit amplitude at each multiple of the pulse frequency (f_s, $2f_s$, $3f_s$ ...). This is what causes copies of the sampled waveform spectrum to get repeated.

The reversed images occur because the full mathematical representation of the original signal's spectrum contains negative frequencies (the full spectrum is, in fact, symmetrical around zero on the frequency axis). The negative frequencies are often not plotted on practical spectra (eg, Fig.3), but are important mathematically.

The idea of negative frequency can seem difficult to grasp. However, mathematically it is easy to verify that

$cos(-x) = cos(x)$ and

$sin(-x) = -sin(x)$

So, if we have a sinewave, there is ambiguity as to whether the frequency (which is related x in the equations) is negative or positive and to fully represent it we have to consider both options.

So far we have discussed the spectrum of the impulse train version of the sampled signal, but as already noted this is not the form the sampled signal takes in a real circuit. We actually have a sampled-and-held signal (like the bottom trace in Fig.2) and this has a different spectrum. The spectrum of the sampled-and-held waveform is obtained from that of the impulse train by multiplying it by the *sinc* function. The *sinc* function is related to the *sine* function, specifically we have:

$sinc(x) = sin(\pi x)/\pi x.$

This is illustrated in Fig.6, which shows the impulse train spectrum from Fig.5, together with the sinc function. Fig.7 shows the actual spectrum of the sampled-and-held waveform. It can be seen that unwanted frequencies in the sampled signal are significantly reduced in the sampled-and-held version, but they are still there, so we still need a low-pass filter to remove them.

Filtering

The filtering requirements are complicated by the fact that the spectrum of the original signal is distorted by the sinc function. The low-pass filter should, therefore, compensate for this by boosting the signal by *1/sinc(x)* up to the cut-off frequency. The required filter response is illustrated in Fig.7. It may also be possible to modify the stored data in the sequence generator (Fig.1) to compensate for the sinc function.

The idea that a sampled signal can contain frequencies right up to the Nyquist frequency (half the sampling frequency) assumes that we can use an ideal 'brick wall' reconstruction filter with infinitely fast cut-off. Of course, this is not possible in practice and we need some margin for non-ideal filter performance. Having a less demanding limit on the maximum frequency also reduces the amount of distortion caused by the sinc function in the sampled and held spectrum, as this get worse closer to the Nyquist frequency.

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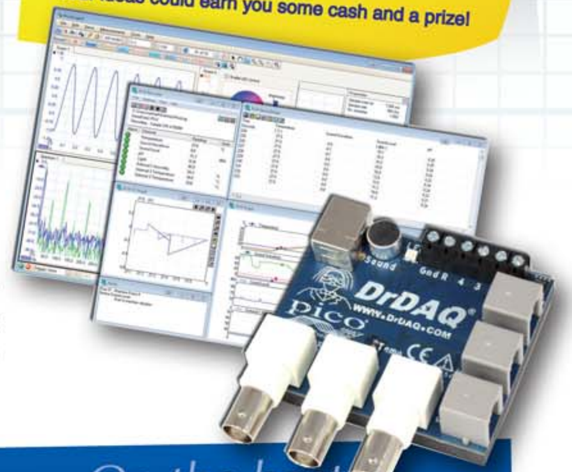

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LRC Beat Balance Metal Detector – *On the beat*

IN 2004, I introduced the concept of a beat balance (BB) metal detector in *EPE*. The circuit of Fig.1 shows a new, experimental BB embodiment, which is completely self-contained – and, with the use of just ten components, has the potential to pick up an old Victorian penny at 180mm. This is likely to be the biggest 'bang-for-buck' available from any self-contained metal detector design today.

The LRC Beat Balance Metal Detector is based on two novel LRC (inductor-resistor-capacitor) oscillators, which are built around a dual CMOS 556 timer (IC1). Note that older, bipolar devices are not suitable here. The CMOS ICM7556 version is recommended – although two CMOS TLC555s were tested successfully, and two ICM7555s would suit perfectly.

The frequency of the two oscillators is equalised through VR1, so that a beat frequency is created in the crystal earpiece X1. A piezo sounder may be used for X1, but will not be as practical. Ideally, VR1 should be a multiturn potentiometer, for adequate control of the tuning.

Coil info

Fig.2 shows how the coils are wound. These are placed out-of-phase on the search head, as shown in the diagrams (R and L indicate right and left when the wires are facing you). The amount of overlap is suggested in Fig.2, but may be experimented with. Note that the metal detector may only perform little better than a beat frequency operation (BFO) metal detector if care is not taken with the overlap. With this in mind, it is suggested that the metal detector be set up by moving the coils in minute increments, retuning each time with VR1 to establish the greatest sensitivity through trial and error.

With an old Victorian penny, a frequency shift of one tone in X1 at 180mm is proven. However, such sensitivity may require time and patience. A more easily realisable, or interim goal would be 140mm – happy metal hunting!

Thomas Scarborough, South Africa

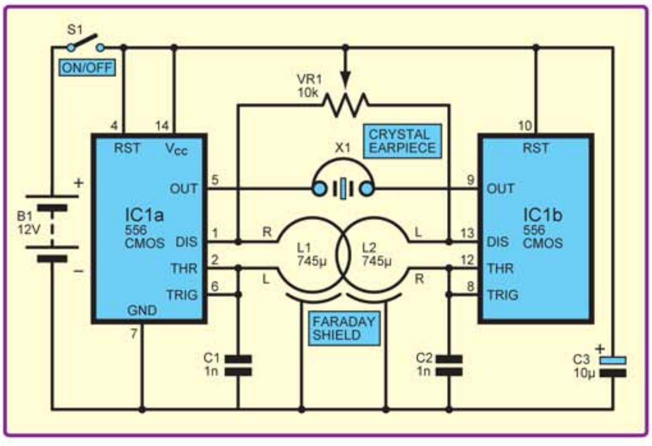

Fig.1. Circuit diagram for a LCR Beat Balance Metal Detector

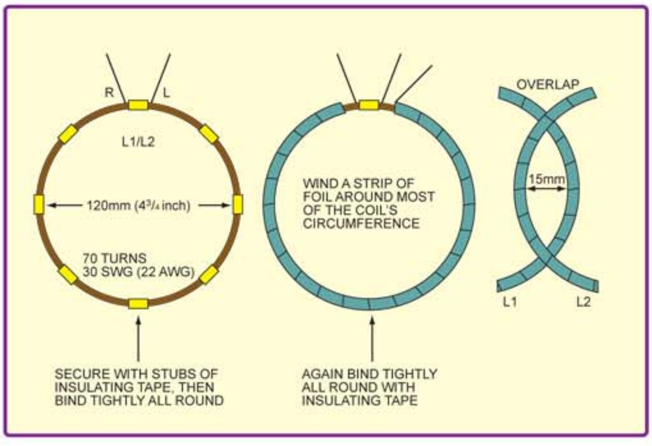

Fig.2. Detector coil winding details

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Using 5V LCDs with 3.3V processors

THE 2 line × 16 character LCD display module has been a staple of the hobbyist microcontroller engineer's toolkit for decades. Easy to wire up (requiring only seven data signals and a single 5V supply), and with low power consumption, they provide the bridge between the user and the world of options and information hiding within a project.

After flashing an LED, it is normally the next piece of functionality to be brought to life, and it is invaluable for debugging purposes, even if the final design does not use a display. Some of our own projects have even used two displays to assist with complex software debugging. Writing to a display is quite a quick operation and does not interfere with the operation of a system, unlike trying to dump data through a slow serial link.

No match

As the years have passed, more complex and interesting displays have become available, and finally cheap enough to compete with the 2 × 16 display – monochrome graphics, colour TFT and now ultra-thin OLED displays. None of these, however, match the older character display's flexibility – they are either too expensive, too fiddly to connect to, require too much CPU/RAM resources, or are too difficult to mount inside a box. A character display, on the other hand, can be bolted onto a case with simple hand tools, wired up one handed and the driver code written in a handful of assembler or C commands. It's just so versatile.

Micro evolution

Unfortunately, as the years passed, microcontrollers evolved too – in particular, to lower working voltages. Processors in the PIC24, dsPIC33 and PIC32 ranges all run at 3.3V, but the venerable character LCD display has remained at 5V, with the exception of a few lower working parts, which are more expensive and difficult to obtain. This, clearly, presents a problem for us to solve.

There are a number of reasons why these LCD's maintain the higher working voltage. The liquid crystal fluid that fills the thin gap between the sheets of glass requires a relatively 'high' voltage to operate across the temperature range, and at low voltages the displays can have either too low a contrast ratio, or take an unacceptably long time to refresh (while testing displays at –5°C once, we observed a display take several seconds to change from one page of text to another – quite comical!)

The other reason is that to produce displays at such low costs, the driver ICs are built on old silicon fabrication processes that are cheap to operate; the newer IC fabrication processes create chips with lower working voltages, but are more expensive, and that cost gets passed onto us. There is also the obvious economy of scale, with the 5V parts having many more uses around the world, and therefore being mass produced more efficiently.

Work-around

There are a number of ways in which a 5V LCD can be incorporated into a 3V processor system. The first involves using logic level shifting ICs, which will shift the voltages either up or down. These can be either specialised devices, designed to perform this at a guaranteed high speed in both directions, or standard TTL logic ICs and some low voltage CMOS families. The drawback is it's another one or two chips to source for your project, and a more complex PCB layout.

Fortunately for us, Microchip have anticipated the problem of mixed voltage working and their processors in the PIC24, dsPIC33 and PIC32 family provide a simple solution. Simple that is, with a little programming!

These processors include some I/O pins that tolerate 5V being applied to them. As an example, the dsPIC33FJ128GP802, shown in Fig.1, highlights the 5V-tolerant pins. There aren't many pins, just seven, but that's enough for driving an LCD display in 4-bit data mode.

The 'trick' to using these pins is to drive them in a novel way. Rather than wiring them as outputs and writing a '1' to the output latch for a high voltage, '0' for a low, we wire a pull-up resistor to each pin (10kΩ should suffice) and set the pins to an input for a high voltage, or output, low, for the low voltage.

This is very simple to do in practice – write a '0' to the output latch register at the beginning of your program, and then toggle the TRIS register rather than the LAT register to drive your signals onto the pin. It seems strange, but works well. If you need to generate a fast signal (which we don't for a standard LCD) then you can lower the value of the pull-up resistor to say 1kΩ. For our application, with short connections between the LCD and the display, 4k7 to 10kΩ will be fine, the value is not that critical.

The one drawback to this scheme is that standard LCD driving libraries are no longer of any use; they work by toggling the LAT registers, not the TRIS. Fortunately, the code to drive an LCD is trivial, and we have supplied the routines to do this (tailored for a dsPIC33FJ part, but written in C and suitable for any of the processors mentioned, with a little modification.) The files can be found on the magazine's website.

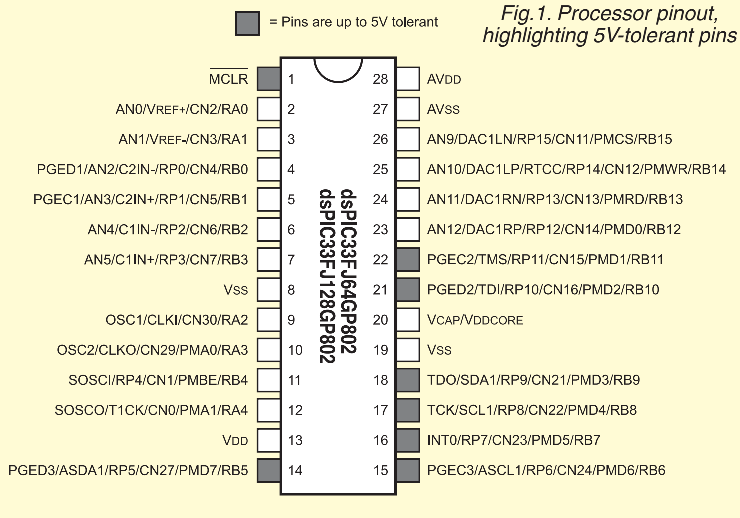

Fig.1. Processor pinout, highlighting 5V-tolerant pins

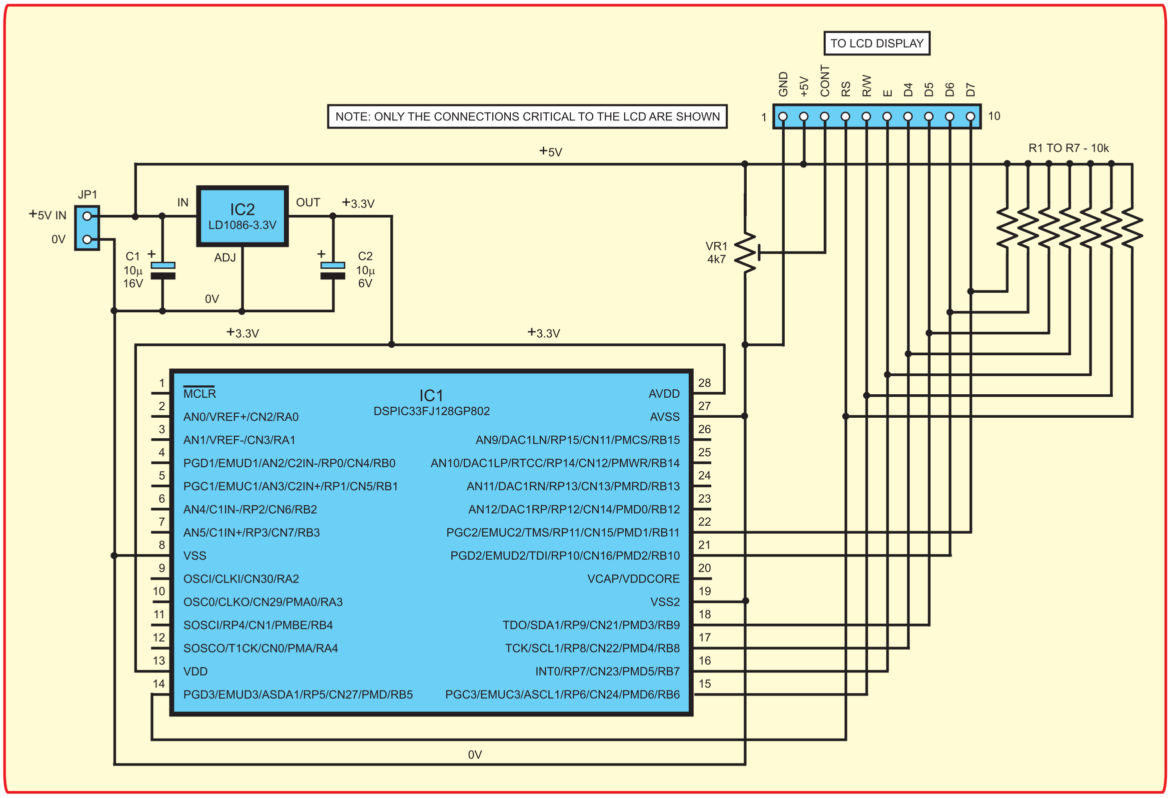

Fig.2. Connecting a 5V LCD to a 3.3V processor. Only connections critical to the LCD are shown

Connecting up

An example circuit, showing the connections of an LCD to a dsPIC processor, is illustrated in Fig.2. Only the parts critical to the LCD circuit are shown, so MCLR pull-up, supply capacitors and crystal oscillator parts are not present. These would be implemented in the normal way for a standard 3.3V circuit. Note that the LCD supply voltage and the contrast adjustment resistor are wired to 5V, along with the pull-ups.

You can now see why the recent *PIC n' Mix* hardware designs have started using 5V mains supplies to power them; it provides the source of the regulated supply for the 5V parts, saving on the cost of a second regulator. You can, of course, use a second regulator if you wish, and then power your circuits from a higher voltage standard 'power brick'. 5V power supplies are becoming very common now, and are very cheap, but care should be taken when powering your own digital creations; we have found some of the cheap phone charger supplies give out over 6.5V, even under load. This could exceed the LCD maximum voltage rating and destroy it. Ensure any supply used is outputting 5V within ±10% max.

An added benefit of using a 5V supply is that the voltage dropped by the regulator, 1.7V, significantly reduces the heat that has to be dissipated by the regulator. This means you can choose a smaller regulator IC package, and possibly do away with any heatsink.

As a closing point, it's interesting to note that the dsPIC30 series of processors do not include any 5V-tolerant parts, making them something of an oddity in the high-end processor families. Maybe something for another article!

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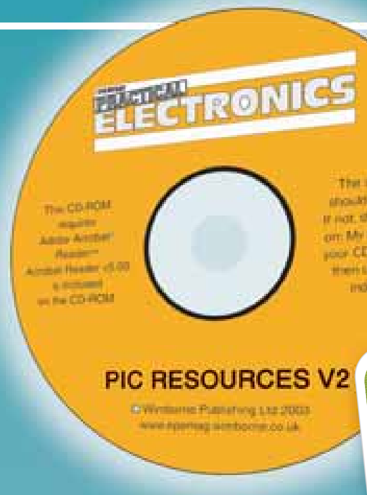

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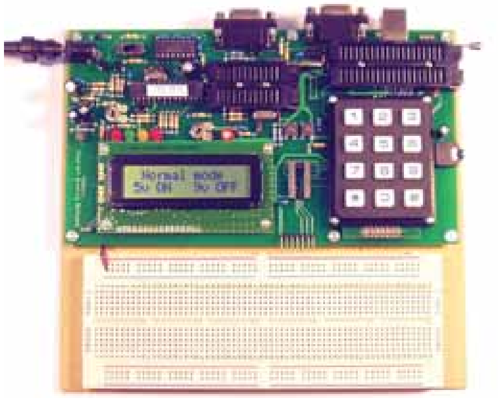

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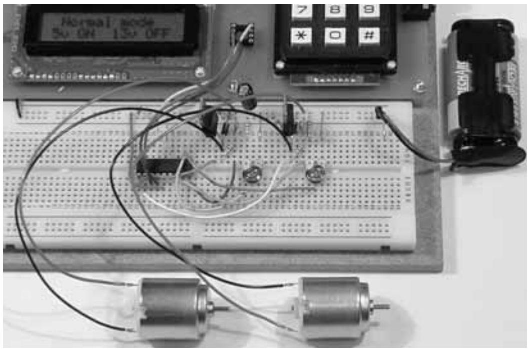

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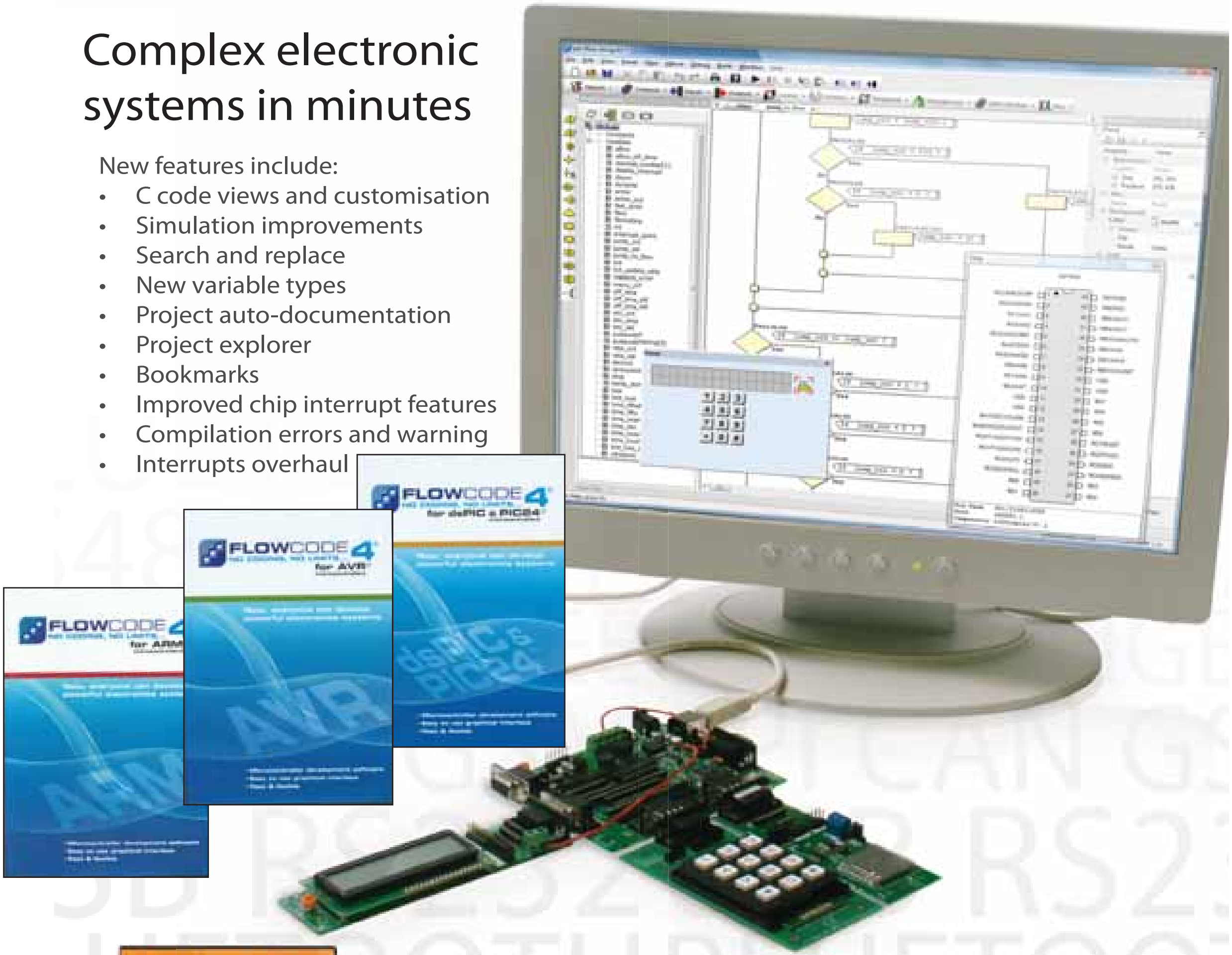

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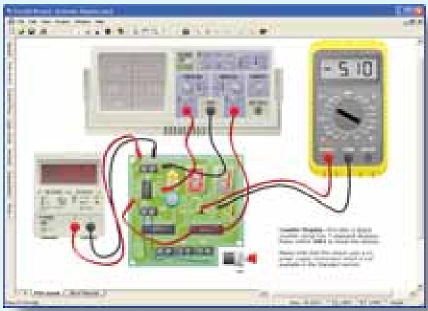

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NET WORK

by Alan Winstanley

Going QRazy

WELCOME to this month's *Net Work*, the column written to help *EPE* readers get more from the Internet.

I've just returned from a major DIY store after using a timely 20% discount voucher that was emailed to me before Christmas – thanks to **www.myvouchercodes.co.uk** – and in the store's car park was a van with a giant QR code printed on the tailgate. (Whether they expect car drivers to scan it on their phones as they drive by at 70mph I'm not sure, but it intrigued a few folks in the parking lot anyway.)

In previous columns, I explained the use of Quick Response or QR codes, those pixelated 'barcodes' that appear on adverts, posters and now, vans. QR codes can contain URLs, product codes, promotional messages or simple text. Curvy, stylised QR codes are also appearing: unlike 2D stripey barcodes, which have tight specs. for colour schemes and contrast, a QR code can be enhanced with colour or Photoshop trickery and it will still scan properly.

Of course, a mobile phone suitably equipped with an app. can easily scan QR codes. The British supermarket chain Tesco, one of the world's largest retailers (and the name behind Fresh & Easy in the US), partnered with Samsung to devise a new Homeplus 'virtual store' in Korea using photo-realistic images of supermarket shelves carrying life-size groceries; busy Korean commuters just browse the back-lit billboard 'aisles' in a sub-way and scan QR codes with their smartphones to add items to their virtual basket. The goods are then delivered to their door after they get home. The use of QR codes in Tesco's virtual stores made Homeplus the No. 1 in the online market, they claim. (See the movie at **http://youtube/fGaVFRzTTP4** and others, for more details.)

It's still early days in the UK, but enigmatic QR codes are now appearing on mailshots in the post or dropped into our shopping – a QR postcard just arrived from Go Daddy in the US; simply scan them to visit a website, take a survey, earn a discount or learn about the latest offers. I've noticed though that my old-generation VGA webcam stares blankly at me when I try waving a QR code before its cyclopean eye (remembering that a program such as QuickMark needs to be running at the same time). I've concluded that my old webcam simply isn't up to the challenge of scanning these new marvels of matrices – time for an upgrade!

Pixelated

How image resolutions have rocketed in the past 15 years. Among the earliest digital cameras in the UK was the groundbreaking Casio QV-10A, which produced images at a paltry 320 × 240 (quarter-VGA) pixels. First to catch the tide were Britain's trendy estate agents (realtors), but disappointment awaited their clients as the resulting pixelated images of householders' properties made them barely recognisable. You can visit the Casio Archive and see more details of the QV-10A at **http://tinyurl.com/czrtghp**.

A year or two passed before consumer VGA (640 × 480) digicams appeared. Technology has raced on since the era of the QV-10, but coincidentally QVGA 320 × 240 is the resolution offered by many PDA and smartphone LCD displays today: hence the need for 'mobile' versions of sprawling web sites. Having made my hyperopic webcam redundant, a 2-megapixel HD webcam recently arrived in the shape of a Logitech Webcam Pro 9000. This HD 720p USB web camera has a Carl Zeiss lens and built-in microphone, and it boasts auto focus, face tracking and close-up shooting too.

If you're sensitive about such things, an older VGA camera will be kinder to those wishing to show themselves in a more soft-focus style, as the picture and clarity of the newest HD cameras are remarkable in comparison, showing individual strands of hair (or lack of them) in detail. The Logitech 9000 is fine value at £35, given that its VGA predecessor cost half as much again. Skype users tell me that the enhanced picture is quite remarkable.

One big disappointment I found was its 'Rightlight' auto exposure feature that constantly produced over-exposed ghost-like images – precisely what Logitech claims the camera strives to avoid. Perhaps the office window or my spotlights adversely

A Korean shopper orders groceries, using his mobile phone to scan QR codes in Tesco's virtual supermarket (see YouTube)

QR codes can be scanned onto desktops with modern webcams such as the HD Logitech Webcam Pro 9000. (Photo: Author)

affected the metering, but eventually I turned the Rightlight feature off and just used the manual settings instead.

However, this webcam has many video tricks up its sleeve that compensate for its shortcomings: Logitech's webcam uses basic facial recognition to generate animated avatars and picture effects with impressive results. After calibrating the subject to pinpoint their features, the webcam can superimpose a range of fun effects, such as a false nose and moustache, a pair of glasses, long hair or lots more. I soon had one Skype user in stitches!

The camera can also automatically track your face, following you around the room quite eerily. Its motion detection software can capture movement and record video clips to hard disk, which could be used to help guard your desktop or office. Avatar personalities can be adopted too, so that an animated cat or robot can lip-sync by tracking your head and eye movements. This works best on a faster PC, as some of the characters are CPU-intensive.

Now for the acid test – when firing up QuickMark and trying a QR postcard, I found that the HD Webcam Pro 9000 made all the difference. After allowing the webcam to autofocus briefly – the camera hunts sometimes for a few seconds – the QR code was captured even at awkward angles and my web browser opened at the intended website. Overall, I've been very surprised by the great improvements in picture quality and features since earlier generations of webcams, and Internet enthusiasts might want to put an HD webcam on their New Year wishlist.

Shrinking emails

Another common application for Internet users is sending images by email. Only a few years ago, in order to circulate snapshots among friends, web design and FTP software might be needed to upload a simple webpage with some photos, and then send the URL to recipients. Some readers might use a photo-sharing website such as Yahoo Flickr, Photobucket or Google Picasa to publish a gallery of photos, or you might look at our *Web In A Box* project, which can host photos or simple webpages over a home network. It's become second nature to email images as file attachments, and smartphones make it easy to upload snapshots or videoclips directly onto Facebook.

Some of the background considerations of emailing images are often overlooked, and the same basic principles also apply when designing simple web pages containing photographs. It might be useful to start with a few common terms that Internet users come across, especially if you are considering designing your own web pages. You will want your emails and web pages to load as quickly as possible, and take up minimal storage space, and so the correct image format helps with these aspects.

The *JPEG* (Joint Photographic Expert Group) is the standard file format for photographic images, while *GIFs* (graphics interchange format) are designed for low-quality images or web graphics, which contain large areas of solid colour. Latterly, the *PNG* (portable network graphic) format has become a potential GIF replacement, intended for website viewers only.

Graphics software such as Corel's Paint Shop Pro, Adobe Photoshop or Serif PhotoPlus can help with photo manipulation or converting images into other formats. Cropping and resizing images are routine operations; do remember to 'sharpen' an image after resizing it.

The best-known free Windows software is probably IrfanView (downloadable from **www.irfanview.com**), which is a surprisingly versatile image editor and batch processor that's fairly simple to use. You can also edit or rename a whole folder of images powerfully with a mouse-click (useful for digicam owners). More challenging to use is GIMP, a freeware program for Windows, Mac and Linux, which can be downloaded from: **www.gimp.org**.

It's a zip

The general increase in Internet bandwidth, coupled with much larger computer screen sizes, and higher screen resolutions, means that it's possible to host on the web much larger images (in terms of pixel size) than before, without fear of courting unpopularity. However, there are several ways in which server space can be saved and transmission speed can be improved.

An image's compression factor affects the file size: the higher the compression the faster the image will load, and the less disk space and bandwidth it will need. Graphics software can compress jpegs by 20% or more to make a smaller file, suitable for emailing or web use. A 2MB jpeg can easily compress down to under 100kB or so, and it will still be adequate for on-screen viewing. GIFs have less scope for optimisation.

Mailbigfile is a recommended 'freemium' service for sending large files over the Internet without clogging up people's email

I may also zip multiple files together into one convenient file, using WinZIP (**www.winzip.com**) or open-source 7zip (**http://7-zip.org**), if I know the recipient can handle zip files. WinZip displays a bargraph showing the level of compression that it has been able to apply. It's probably slightly impolite to email file attachments over, say, 7MB to 10MB in total.

It is easy enough to choke off a recipient's mailbox with unduly large files (which may include .zip files, jpegs, PDFs or more); file sizes can be viewed in Windows by right-clicking and choosing 'Properties', or checking them in Explorer using the Details view. As camera users know, raw digital camera files can be massive, which creates similar problems.

Freemium benefits

Beyond file size of 10MB or so, it's probably better to use a reputable third-party service such as MailBigFile to send files. A key benefit is that the recipient can then download it at their convenience, instead of having their email choked up. Mailbigfile's consumer-friendly free service allows up to 300MB to be emailed to one address. For £12.00 ($20) a year, an upgraded Mailbigfile 'Pro' account offers an address book and higher 2GB file limits, an example of what has been dubbed a 'freemium' service: a freebie offering paid-for enhancements. Another new freemium service called StoreBigFile (**www.storebigfile.com**) from the same vendors offers to host your files securely in their 'cloud'. Free users enjoy 1GB of space and five email addresses.

The latest version of WinZip (v16.0) offers a 'ZipSend' service, which turns out to be provided by YouSendIt. Their free limit is 2GB of online file storage and 50MB file size, but perpetual storage is offered. To send up to 2GB costs $4.17 a month.

Having outlined the basic image considerations, some *EPE* readers will be looking at creating their own webpages, especially if they are contemplating the *Web In A Box* project. Only the most basic of webpages can be crafted entirely by hand using HTML code, but high-end software packages such as Dreamweaver are overkill for most simple web-pages.

Microsoft Word will save a page as a bloated HTML file, or a simple free HTML editor such as Serif WebPlus Starter Edition (**http://www.serif.com/web-design-software**) will get you going. You could try the free trial of Coffee Cup HTML Editor from **www.coffeecup.com**. Themes or templates may be included that offer some styled pages for you.

In the next *Net Work*, I'll look again at some online storage options. You can email me at **alan@epemag.demon.co.uk** or write to **editorial@wimborne.co.uk** for possible inclusion in *Readout*.

READOUT

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? **Drop us a line!**

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All letters quoted here have previously been replied to directly

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★ LETTER OF THE MONTH ★

Free energy?

Dear editor
The inventive Thomas Scarborough wrote an article (*EPE*, January 2002) on a simple circuit to flash an LED. Although the circuit was powered from a 9V battery, its consumption was so low that it could be powered instead from 'free energy' picked up from an 'aerial' and 'earth' connection.

It aroused my curiosity, and I built a similar circuit using two discrete transistors, which showed that with careful selection of 'earth' and 'aerial' connections, sufficient power could be picked up to pulse the LED at a slow rate. My investigations showed that, in my case, all the energy was being derived from 50Hz pickup. This isn't so surprising; many of us will have seen a 50Hz pickup signal on a high-impedance oscilloscope probe when the probe tip is touched.

My test used the earth connection of my ring-main supply, which is earthed via the armoured cable of the supply company. A typical ring main is implemented with 2.5mm CSA twin and earth cable. I measured the capacitance of one metre of this, and found it to be about 150pF from earth to live and earth to neutral.

At 50Hz, 150pF has an impedance of 21MΩ. Thus, the impedance from live and neutral to earth over a ring-main run of say 50m will be down to about 400kΩ – not to be confused with the insulation resistance measured at DC.

Since the pickup is associated with small values of stray capacitance, the impedance levels are going to be quite high, and measuring it is a problem, requiring high-impedance circuits. The normal input impedance of DMMs and CROs is 1MΩ, which is not high enough. Some probes have a 10:1 divider input, giving a 10MΩ input impedance, which is a significant improvement, but still not adequate in this case.

To create a high impedance system, I used a set of 10MΩ resistors to make a divider having a 200MΩ input impedance, and thereby make some pickup measurements. The lower divider resistor was 10MΩ and a 10:1, 10MΩ CRO probe was connected across it. Although this lowered the effective divider ratio, it did not significantly change the input impedance of the divider as a whole.

The resistors were closely spaced on a small piece of plug board, which was put on top of an earthed sheet of copper to reduce the pickup from the divider itself. The divider ratio with the probe connected was measured as 390:1 with a 24V AC supply.

My 'aerial' connection was the metal of an unearthed desk lamp (switched off at the lamp) and with the above divider, a 50Hz pickup signal was measured with a peak-to-peak value of 246V! Measurement with a 100MΩ divider and a 10MΩ probe implied that the open-circuit voltage was about 285V pk-pk, with an output impedance of about 32MΩ.

The next stage was to connect two diodes in the form of a peak-to-peak rectifier, with a capacitor to get a DC supply. The capacitor I used was a 4.7µF 400V capacitor (taken from a CF lamp) and the diodes were type 1N4004. With the divider connected, the capacitor slowly charged up to 133V over a period of a few minutes.

If the divider was disconnected from the capacitor and, then after a few further minutes reconnected, the voltage measured was 205V, indicating that the divider was having some loading effect. With no divider, there is still some leakage in the capacitor and diodes.

All very interesting, but what are the implications?

1. It is possible to draw a small amount of energy from stray capacitance to the mains supply to obtain a low-power circuit.

2. Significantly high voltages can be achieved, but with a very high impedance level, and hence limiting the current which can be drawn.

3. The energy is not 'free'. It still flows through the supply meter, but is so small as to probably be undetectable.

If the mains supply to the house is switched off, then this energy source disappears!

Ken Naylor, by email

Thomas Scarborough replies from Cape Town:

Ken is probably referring to the article by Mark Nelson – and my article was surely the Forever Flasher. That one was entered by some students in the National Science Olympiad here, and won second prize. In other experiments with free energy, I was able to power micropower circuits from pot plants wired in series (Google 'Pot Plant Power'), and also with a germanium oscillator wired between a tree and ground. I offered Pot Plant Power to Ingenuity Unlimited *incidentally, but this was rejected for being 'silicon challenged'.*

Matt Pulzer replies:

Apologies Thomas – it must have been geranium powered – what were we thinking of?! Ed.

A fascinating experiment Ken, well done. I just want to add a word of caution for our less experienced readers. Please **DO NOT** *experiment with your domestic ring main unless you really do know what you are doing and know exactly how to take all necessary safety precautions.*

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The CD-ROM also contains all of the software for the *Teach-In 2* series and *PIC N' Mix* articles, plus a range of items from Microchip – the manufacturers of the PIC microcontrollers. The material has been compiled by Wimborne Publishing Ltd. with the assistance of Microchip Technology Inc.

The Microchip items are: MPLAB Integrated Development Environment V8.20; Microchip Advance Parts Selector V2.32; Treelink; Motor Control Solutions; 16-bit Embedded Solutions; 16-bit Tool Solutions; Human Interface Solutions; 8-bit PIC Microcontrollers; PIC24 Mircontrollers; PIC32 Microcontroller Family with USB On-The-Go; dsPIC Digital Signal Controllers.

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The free cover-mounted CD-ROM is the complete *Electronics Teach-In 1* book, which provides a broad-based introduction to electronics in PDF form, plus interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In 1 series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In 1 series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC. There is also a MW/LW Radio project in the series. The contents of the book and Free CD-ROM have been reprinted from past issues of *EPE*.

160 pages | Order code ETI3 | £8.50

Book and CD-ROMs | Order code ETIBUNDLE | Bundle Price **£14.00**

NEW

ELECTRONICS TEACH-IN 4

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ELECTRONICS TEACH-IN 4

A Broad-Based Introduction to Electronics plus FREE CD-ROM

The Teach-In 4 book covers three of the most important electronics units that are currently studied in many schools and colleges. These include, Edexcel BTEC level 2 awards and the electronics units of the new Diploma in Engineering, Level 2.

The Free cover-mounted CD-ROM contains the full Modern Electronics Manual, worth £29.95. The Manual contains over 800 pages of electronics theory, projects, data, assembly instructions and web links.

A package of exceptional value that will appeal to all those interested in learning about electronics or brushing up on their theory, be they hobbyists, students or professionals.

Available NOW – see page 24 in this issue for details

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS AND CDROMS SEE THE UK SHOP ON OUR WEBSITE

www.epemag.com

All prices include UK postage

2

COMPUTING AND ROBOTICS

WINDOWS XP EXPLAINED
N. Kantaris and P. R. M. Oliver

If you want to know what to do next when confronted with Microsoft's Windows XP screen, then this book is for you. It applies to both the Professional and home editions.

The book was written with the non-expert, busy person in mind. It explains what hardware requirements you need in order to run Windows XP successfully, and gives an overview of the Windows XP environment.

The book explains: How to manipulate Windows, and how to use the Control Panel to add or change your printer, and control your display; How to control information using WordPad, notepad and paint, and how to use the Clipboard facility to transfer information between Windows applications; How to be in control of your filing system using Windows Explorer and My Computer; How to control printers, fonts, characters, multimedia and images, and how to add hardware and software to your system; How to configure your system to communicate with the outside world, and use Outlook Express for all your email requirements; how to use the Windows Media Player 8 to play your CDs, burn CDs with your favourite tracks, use the Radio Tuner, transfer your videos to your PC, and how to use the Sound Recorder and Movie Maker; How to use the System Tools to restore your system to a previously working state, using Microsoft's Website to update your Windows set-up, how to clean up, defragment and scan your hard disk, and how to backup and restore your data; How to successfully transfer text from those old but cherished MS-DOS programs.

264 pages | Order code BP514 | £7.99

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages + Large Format | Order code BP901 | £14.99

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision command system

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

298 pages | Order code BP902 | £14.99

THE PIC MICROCONTROLLER
YOUR PERSONAL INTRODUCTORY COURSE – THIRD EDITION John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised third edition covers the popular reprogrammable Flash PICs: 16F54/16F84 as well as the 12F508 and 12F675.

270 pages | Order code NE36 | £25.00

INTRODUCTION TO MICROPROCESSORS AND MICROCONTROLLERS – SECOND EDITION
John Crisp

If you are, or soon will be, involved in the use of microprocessors and microcontrollers, this practical introduction is essential reading. This book provides a thoroughly readable introduction to microprocessors and micrcontrollers. Assuming no previous knowledge of the subject, nor a technical or mathematical background. It is suitable for students, technicians, engineers and hobbyists, and covers the full range of modern micros.

After a thorough introduction to the subject, ideas are developed progressively in a well-structured format. All technical terms are carefully introduced and subjects which have proved difficult, for example 2's complement, are clearly explained. John Crisp covers the complete range of microprocessors from the popular 4-bit and 8-bit designs to today's super-fast 32-bit and 64-bit versions that power PCs and engine management systems etc.

222 pages | Order code NE31 | £29.99

EASY PC CASE MODDING
R.A Penfold

Why not turn that anonymous grey tower, that is the heart of your computer system, into a source of visual wonderment and fascination. To start, you need to change the case or some case panels for ones that are transparent. This will then allow the inside of your computer and it's working parts to be clearly visible.

There are now numerous accessories that are relatively inexpensive and freely available, for those wishing to customise their PC with added colour and light. Cables and fans can be made to glow, interior lights can be added, and it can all be seen to good effect through the transparent case. Exterior lighting and many other attractive accessories may also be fitted.

This, in essence, is case modding or PC Customising as it is sometimes called and this book provides all the practical details you need for using the main types of case modding components including:- Electro luminescent (EL) 'go-faster' stripes: Internal lighting units: Fancy EL panels: Data cables with built-in lighting: Data cables that glow with the aid of 'black' light from an ultraviolet (UV) tube: Digital display panels: LED case and heatsink fans: Coloured power supply covers.

192 pages + CD-ROM | Order code BP542 | £8.99

ROBOT BUILDERS COOKBOOK
Owen Bishop

This is a project book and guide for anyone who wants to build and design robots that work first time.

With this book you can get up and running quickly, building fun and intriguing robots from step-by-step instructions. Through hands-on project work, Owen introduces the programming, electronics and mechanics involved in practical robot design-and-build. The use of the PIC microcontroller throughout provides a painless introduction to programming – harnessing the power of a highly popular microcontroller used by students, hobbyists and design engineers worldwide.

Ideal for first-time robot builders, advanced builders wanting to know more about programming robots, and students tackling microcontroller-based practical work and labs.

The book's companion website at http://books.elsevier.com/companions/9780750665568 contains: downloadable files of all the programs and subroutines; program listings for the Quester and the Gantry robots that are too long to be included in the book.

366 pages | Order code NE46 | £26.00

THEORY AND REFERENCE

GETTING THE MOST FROM YOUR MULTIMETER
R. A. PenfoldM
This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**

OSCILLOSCOPES – FIFTH EDITION
Ian Hickman
Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models are available.

This handy guide to oscilloscopes is essential reading for anyone who has to use a 'scope for their work or hobby; electronics designers, technicians, anyone in industry involved in test and measurement, electronics enthusiasts . . . Ian Hickman's review of all the latest types of 'scope currently available will prove especially useful for anyone planning to buy – or even build – an oscilloscope.

The contents include a description of the basic oscillscope; Advanced real-time oscilloscope; Accessories; Using oscilloscopes; Sampling oscilloscopes; Digital storage oscilloscopes; Oscilloscopes for special purposes; How oscilloscopes work (1): the CRT; How oscilloscopes work (2): circuitry; How oscilloscopes work (3): storage CRTs; plus a listing of Oscilloscope manufacturers and suppliers.

288 pages **Order code NE37** **£36.99**

UNDERSTANDING ELECTRONIC CONTROL SYSTEMS
Owen Bishop
Owen Bishop has produced a concise, readable text to introduce a wide range of students, technicians and professionals to an important area of electronics. Control is a highly mathematical subject, but here maths is kept to a minimum, with flow charts to illustrate principles and techniques instead of equations.

Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.

The text is supported by questions under the headings Keeping Up and Test Your Knowledge so that the reader can develop a sound understanding and the ability to apply the techniques they are learning.

228 pages **Order code NE35** **£36.99**

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold
This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages **Order code BP332** **£5.45**

PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.
Bridges the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias – tedious and higher mathematics have been avoided where possible and many tables have been included.

The book is divided into six basic sections: Units and Constants, Direct-Current Circuits, Passive Components, Alternating-Current Circuits, Networks and Theorems, Measurements.

256 pages **Order code BP53** **£5.49**

MICROCONTROLLER COOKBOOK
Mike James
The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages **Order code NE26** **£36.99**

FULL COLOUR COMPUTING BOOKS

HOW TO FIX YOUR PC PROBLEMS **R.A. Penfold**
What do you do when your laptop or desktop stops working properly. Do you panic, try to find the answer on the page of fault finding tips you may find at the back of the manufacturers manual. Or do you spend hours trying to get through to a telephone helpline or waste even more time waiting for an email reply from a helpdesk.

Well help is now at hand! This book will assist you in identifying the type of problem, whether it's hardware, software or a peripheral that is playing up? Once the fault has been identified, the book will then show you how to go about fixing it. This book uses plain English and avoids technical jargon wherever possible. It is also written in a practical and friendly manner and is logically arranged for easy reference.

The book is divided into four main sections and among the many topics covered are: Common problems with Windows Vista operating system not covered in other chapters. Also covers to a lesser extent Windows XP problems. Sorting out problems with ports, peripherals and leads. Also covers device drivers software and using monitoring software. Common problems with hard disc drives including partitioning and formatting a new drive. Using system restore and recovering files. Also covers CD-ROM and Flash drives. Common problems with sound and video, including getting a multi-speaker system set up correctly.

An extremely useful addition to the library of all computer users, as you never know when a fault may occur!

Printed in full colour on high quality non-refective paper

128 pages **Order code BP705** **£8.49**

AN INTRODUCTION TO WINDOWS VISTA **P.R.M. Oliver and N. Kantarris**
If you have recently bought a new desktop or laptop it will almost certainly have Windows as its operating system. Windows Vista manages the available resource of a computer and also 'controls' the programs that run on it.

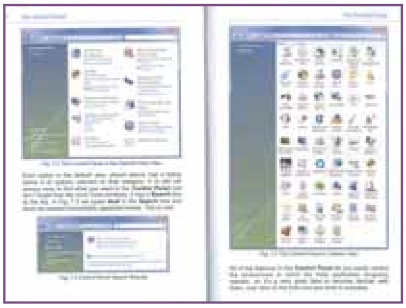
To get the most from your computer, it is important that you have a good understanding of Vista. This book will help you acheive just that. It is written in a friendly and practical way and is suitable for all age groups from youngsters to the older generation. It has been assumed that Vista is installed and running on your computer.

Among the numerous topics explained are: The Vista environment with its many windows. How to organise your files, folders and photos. How to use Internet Explorer for your web browsing. How to use Microsoft Mail for your emails. How to control your PC and keep it healthy. How to use Vista's Accessibility features if you have poor eye sight or difficulty in using the keyboard or mouse. And much more besides....

With the help of this book you will easily and enjoyably gain a better understanding of Microsoft's amazing Windows Vista operating system.

Printed in full colour on high quality non-refective paper

120 pages **Order code BP703** **£8.49**



COMPUTING WITH A LAPTOP FOR THE OLDER GENERATION **R.A. Penfold**
Laptop computers have rapidly fallen in price, increased in specification and performance and become much lighter in weight. They can be used practically anywhere, then stored away out of sight. It is therefore, not surprising that laptop sales now far exceed those of desktop machines and that they are increasingly becoming the machine of choice for the older generation.

You may want to use your laptop as your main computer or as an extra machine. You may want to use your laptop on the move, at home, at work or on holiday. Whatever your specific requirements are, the friendly and practical approach of this book will help you to understand and get the most from your laptop PC in an easy and enjoyable way. It is written in plain English and wherever possible avoids technical jargon.

Among the many topics covered are: Choosing a laptop that suits your particular needs. Getting your new computer set up properly. Customising your computer so that it is optimised for your particular needs. Setting up and dealing with user accounts. Using the Windows 'Ease of Access Center'. Optimising the life and condition of your battery. Keeping the operating system and other software fully up-to-date. Troubleshooting common problems. Keeping your computer and data safe and secure. And much more besides...

Even though this book is written for the older generation, it is also suitable for anyone of any age who has a laptop or is thinking of buying one. It is written for computers that use Windows Vista as their operating system but much will still apply to Windows XP machines. Printed in full colour on high quality non-refective paper

120 pages **Order code BP702** **£8.49**

AN INTRODUCTION TO EXCEL SPREADSHEETS **Jim Gatenby**
The practical and friendly approach of this book will help newcomers to easily learn and understand the basics of spreadsheets. This book is based on Microsoft's Excel 2007 spreadsheet, but much of the book will still apply to earlier versions of Excel. The book is written in plain English, avoiding technical and mathematical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.

Among the many topics explained are how to: Install the software. Use the exciting new features of Excel 2007. Create and use a spreadsheet. Enter, edit and format text, numbers and formulae. Insert and delete columns and rows. Save and print a spreadsheet. Present the information on a spreadsheet as a graph or chart. Manage and safeguard Excel files on disc. Use Excel as a simple database for names and addresses.

This book will help you to quickly gain confidence and get to grips with using spreadsheets. In fact, you will wonder how you ever managed without them.

Printed in full colour on high quality non-reflective paper.

118 pages **Order code BP701** **£8.49**

AN INTRODUCTION TO DIGITAL PHOTOGRAPHY WITH VISTA **R.A. Penfold**
The friendly and practical approach of this book will help newcomers to digital photography and computing to easily learn the basics they will need when using a digital camera with a laptop or desktop PC. It is assumed that your PC uses Windows Vista, however, if it is a Windows XP machine the vast majority of this book will still apply. The book is written in plain English, avoiding technical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.

Among the many topics explained are how to: Understand the basic features of a digital camera. Transfer photographs from your digital camera to your computer. View your photographs. Save, sort and file your photographs. Manipulate, crop and carry out simple corrections to your photographs. Copy your photographs on to CD or DVD. Print your photographs. Share images with family and friends anywhere in the world by email or with an online album.

This book will help you quickly get to grips with, gain confidence and expand your horizons in the fascinating hobby of digital photography.

Printed in full colour on high quality non-reflective paper.

120 pages **Order code BP700** **£8.49**

COMPUTING & PROJECT BUILDING

eBAY – TWEAKS, TIPS AND TRICKS
R. A. Penfold

NEW

Online auction sites are one of the most popular types of site on the internet, and the most popular of these is the eBay site. On eBay you can buy and sell practically anything at surprisingly low cost, and all from the comfort of your armchair!

This book contains numerous tweaks, tips and tricks covering various aspects of buying and selling on eBay. These tweaks, tips and tricks will help both new and more experienced users of the site to make the most of eBay's facilities while remaining safe and secure.

Among the many topics covered are: Finding the items you require using the eBay search facility: Getting the best prices when buying and selling on eBay: Avoiding both buying and selling scams: Determining the market value for items you intend buying or selling: How to avoid problems that may arise when buying and selling on eBay: Making the most of the various facilities that are built into the eBay site: How to take good photos of items you wish to sell using basic equipment: Using the My eBay page to stay in control of your buying and selling activities: And more besides.

128 pages **Order code BP716** **£7.50**

THE INTERNET – TWEAKS, TIPS AND TRICKS
R. A. Penfold

NEW

Robert uses his vast knowledge and experience in computing to provide you with useful hints, tips and warnings about possible difficulties and pitfalls when using the Internet. This book should enable you to get more from the Internet and to discover ways and means of using it that you may not have previously realised.

Among the many topics covered are: Choosing a suitable browser: Getting awkward pages to display properly: Using Java, spell checkers and other add-ons: Using proxy servers to surf anonymously and privacy facilities so you do not leave a trail of sites visited. Ways of finding recently visited sites you can no longer find: Using download managers to speed up downloads from slow servers. Plus, effective ways and tricks of using search engines to locate relevant info: Tricks and tips on finding the best price for goods and services: Not getting "conned" when buying or selling on eBay: Finding free software: Finding and using the increasing range of Cloud computing services: Tips on selecting the best security settings: Etc,etc,etc.

128 pages **Order code BP721** **£7.50**

FREE DOWNLOADS TO PEP-UP AND PROTECT YOUR PCS
R. A. Penfold

NEW

Robert uses his vast knowledge and experience in computing to guide the reader simply through the process of finding reliable sites and sources of free software that will help optimise the performance and protect their computer against most types of malicious attack.

Among the many topics covered are: Using Windows 7 optimisation wizard: Using Pitstop for advice on improving performance, reducing start up times, etc: Free optimisation scans and the possibility of these being used as a ploy to attack your PC.

Plus, free programs such as Ccleaner, Registry checker and PCPal optimisation software: Internet speed testing sites and download managers: Overclocking sites together with warnings about using this technique: Sites and software for diagnosis of hardware faults, including scanning for out of date drivers and finding suitable replacements: Free Antivirus software and programs that combat specific types of malware: Firewalls: Search engines to identify mystery processes listed in Windows Task Manager.

128 pages **Order code BP722** **£7.50**

HOW TO BUILD A COMPUTER
R.A. Penfold

To build your own computer is, actually, quite easy and does not require any special tools or skills. In fact, all that it requires is a screwdriver, pliers and some small spanners rather than a soldering iron! The parts required to build a computer are freely available and relatively inexpensive.

Obviously, a little technical knowledge is needed in order to buy the most suitable components, to connect everything together correctly and to set up the finished PC ready for use. This book will take you step-by-step through all the necessary procedures and is written in an easy to understand way. The latest hardware components are covered as is installing the Windows Vista operating system and troubleshooting.

320 pages **Order code BP591** **£8.99**

BUILDING VALVE AMPLIFIERS
Morgan Jones

The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.

A unique hands-on guide for anyone working with valve (tube in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.

Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

368 pages **Order code NE40** **£29.00**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

BOOK ORDERING DETAILS

All prices include UK postage. for postage to Europe (air) and the rest of the world (surface) please add £2 per book. For the rest of the world airmail add £3 per book. **Note: Overseas surface mail postage can take up to 10 weeks**. CD-ROM prices include VAT and/or postage to anywhere in the world. Send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or card details, Visa, Mastercard or Maestro to:

DIRECT BOOK SERVICE, WIMBORNE PUBLISHING LIMITED, 113 LYNWOOD DRIVE, MERLEY, WIMBORNE, DORSET, BH21 1UU.

Books are normally sent within seven days of receipt of order, but please allow 28 days for delivery – more for overseas orders. *Please check price and availability (see latest issue of* Everyday Practical Electronics*) before ordering from old lists.*

For a further selection of books see the next two issues of *EPE*.
Tel 01202 880299 Fax 01202 843233. Email: dbs@wimborne.co.uk
Order from our online shop at: www.epemag.com. Go to the 'UK store'.

COMPUTING AND ROBOTICS

NEWNES INTERFACING COMPANION
Tony Fischer-Cripps

A uniquely concise and practical guide to the hardware, applications and design issues involved in computer interfacing and the use of transducers and instrumentation.

Newnes Interfacing Companion presents the essential information needed to design a PC-based interfacing system from the selection of suitable transducers, to collection of data, and the appropriate signal processing and conditioning.

Contents: Part 1 – Transducers; Measurement systems; Temperature; Light; Position and motion; Force, pressure and flow. Part 2 – Interfacing; Number systems; Computer architecture; Assembly language; Interfacing; A to D and D to A conversions; Data communications; Programmable logic controllers; Data acquisition project. Part 3 – Signal processing; Transfer function; Active filters; Instrumentation amplifier; Noise; Digital signal processing.

295 pages **Order code NE38** **£41.00**

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PCB SERVICE

Printed circuit boards for most recent *EPE* constructional projects are available from the *PCB Service*, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. Double-sided boards are **NOT plated through hole** and will require 'vias' and some components soldering to both sides. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, Everyday Practical Electronics, Wimborne Publishing Ltd., 113 Lynwood Drive, Merley, Wimborne, Dorset BH21 1UU. Tel: 01202 880299; Fax 01202 843233; Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag.com**. Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only)**.

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail. Back numbers or photocopies of articles are available if required – see the Back Issues page for details. WE DO NOT SUPPLY KITS OR COMPONENTS FOR OUR PROJECTS.

Please check price and availability in the latest issue. A large number of older boards are listed on, and can be ordered from, our website.

Boards can only be supplied on a payment with order basis.

PROJECT TITLE	ORDER CODE	COST
DECEMBER '10		
12V Speed Controller or 12V Lamp Dimmer	781	£8.39
★Digital RF Level & Power Meter		
– Main Board	783 } set	£12.97
– Head-end Board	784	
– RF Attenuator Board	785	
JANUARY '11		
★Multi-Purpose Car Scrolling Display		
– Main Board	786 } pair	£14.65
– Display Board	787	
USB-Sensing Mains Power Switch	788	£11.72
★433MHz UHF Remote Switch		
– Transmitter	789 } pair	£12.14
– Receiver	790	
FEBRUARY '11		
Time Delay Photoflash Trigger	791	£11.66
Tempmaster Mk.2	792	£10.31
MARCH '11		
★GPS Synchronised Clock	793	£9.62
★Digital Audio Millivoltmeter	794	£13.61
Theremin	795	£12.64
USB Printer Share Switch	796	£8.16
APRIL '11		
Multi-Message Voice Recorder	797	£9.04
PIR-Triggered Mains Switch	798	£9.60
★Intelligent Remote-Controlled Dimmer	799	£8.36
MAY '11		
★6-Digit GPS Clock	800	£12.83
Simple Voltage Switch For Car Sensors	801	£8.16
The μCurrent (double-sided, surface mount)	802	£13.80
★Digital Audio Oscillator (double-sided)	803	£14.20
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6-Digit GPS Clock Driver (Pt.2)	806	£8.16
Musicolour IRDA Accessory	807	£7.38
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– Detector	809	
Metal Locator	810	£8.56
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– Antenna/Amp	813 } pair	£10.67
– Radio Loop	814	
AUGUST '11		
Input Attenuator for the Digital Audio Millvoltmeter	811	£7.58
★SD Card Music & Speech Recorder/Player	815	£13.61
★Deluxe 3-Chan. UHF Rolling Code Remote Control – Transmitter	816 } pair	£12.43
– Receiver	817	

PROJECT TITLE	ORDER CODE	COST
SEPTEMBER '11		
★ Digital Megohm and Leakage Current Meter	818	£9.72
Auto-Dim for 6-Digit GPS Clock	819	£6.80
OCTOBER '11		
★ High-Quality Stereo DAC –		
Input & Control Board	820 } set	£20.41
Stereo DAC/Analogue Board	821	
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Power Supply Board	823	
Twin Engine SpeedMatch Indicator	824	£8.75
★ Wideband Air/Fuel Display (double-sided)	825	£14.38
NOVEMBER '11		
★ Digital Capacitor Leakage Meter	826	£10.11
One-of-Nine Switch Indicator		
– Main Board	827 } pair	£11.27
– Remote Display Board	828	
DECEMBER '11		
★ Wideband Oxygen Sensor Controller	829	£11.47
★ WIB (Web Server In A Box)	830	£9.72
★ Ginormous 7-segment LED Panel Meter		
– Master (KTA-255v2)	831	£12.67
– Slave (KTA-256v2)	832	£5.05
– Programmed Atmega328		£10.13
JANUARY '12		
Balanced Output Board For The Stereo DAC	833	£9.72
FEBRUARY '12		
★ Air Quality Monitor (CO_2/CO)	834	£8.75
WIB Connector Daughter PCB	835	£6.80

EPE SOFTWARE

★ All software programs for *EPE* Projects marked with a star, and others previously published can be downloaded free from the Library on our website, accessible via our home page at: **www.epemag.com**

PCB MASTERS

PCB masters for boards published from the March '06 issue onwards can also be downloaded from our website (**www.epemag.com**); **go to the 'Library' section.**

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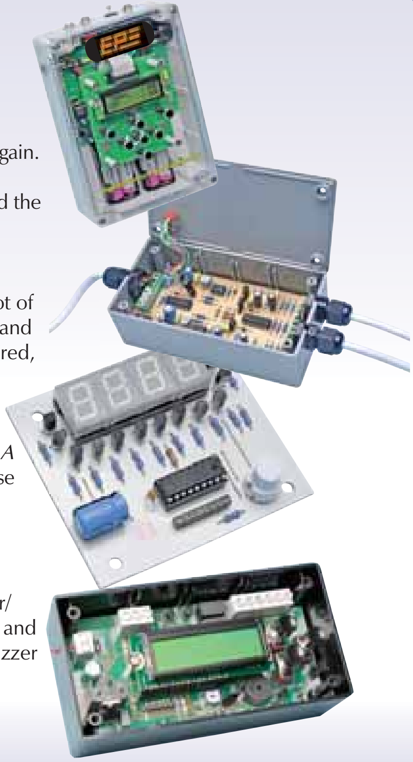
Next Month

Content may be subject to change



High-Quality Digital Audio Signal Generator – Part 1

This really is a 'must have' project!

Audio signal generators are one of those pieces of equipment you will use again and again. The problem is good ones are pricey. This project is the answer to your prayers! It has TOSLINK and coax (S/PDIF) digital outputs, as well as two analogue audio outputs, and the harmonic distortion from its high quality DAC is extremely low.

Solar-Powered Intruder Alarm

Many of us have a shed, and while we often have alarms for our home and cars, a lot of valuable stuff is unprotected in garages and outbuildings. They need protecting too, and now you can do it with this simple alarm based on a PIR sensor. Plus, it's solar-powered, so no mains supply is needed.

WIB add-on: Internet Time Display Module

Need a really accurate clock? This simple add-on board for the WIB *(Web Server In A Box)* displays the time and date, as gathered from an Internet time server. You can use it as a clock you never need to correct, and it can even be configured in the WIB to automatically adjust for daylight saving time.

Very, Very Accurate Thermometer/Thermostat

Based on the precision Dallas DS18B20 digital temperature sensor, this thermometer/thermostat provides excellent readings to one decimal point. Its LCD shows current, and minimum and maximum temperature readings. We've even provided an internal buzzer that will sound when temperature limits are exceeded. Use it with air conditioners, heaters, cool rooms or wine cellars. Oh, and did we mention it's very accurate?

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